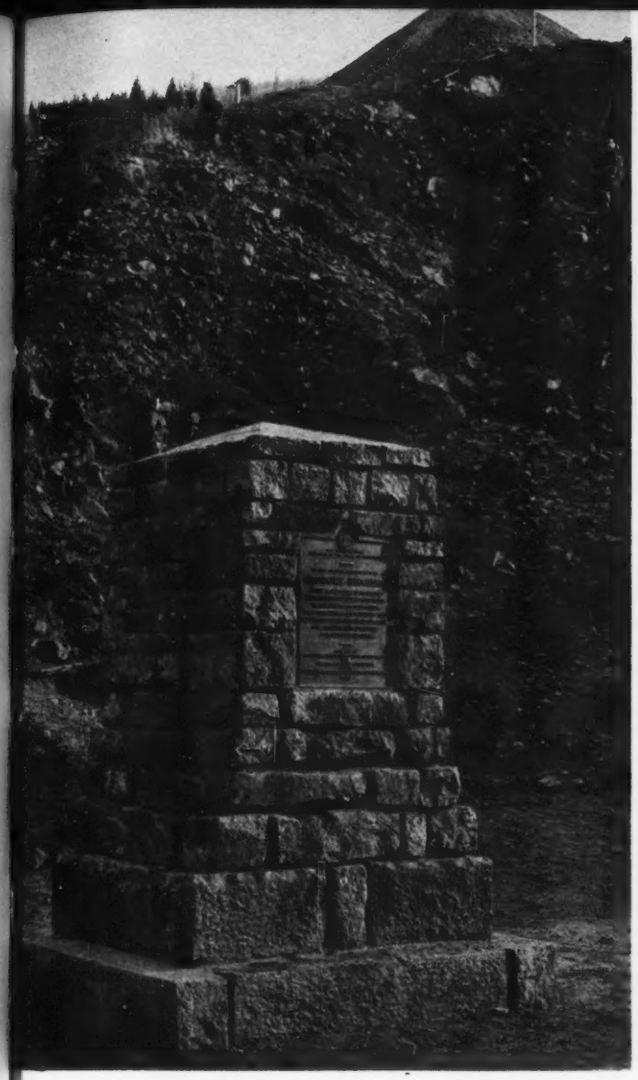

Monument erected at Central City by State Historical Society of Colorado on ground once known as Gregory Diggings, to commemorate discovery by John H. Gregory of first gold lode in Colorado, May 6, 1859. The district has produced $85,000,000 in gold

Engineering and Mining Journal

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Volume 136 AUGUST 1935 Number 8

COLORADO

Storehouse of Varied Mineral Wealth

Seventy-seven years of mining have yielded gold, silver, copper, lead, zinc, tungsten, radium, molybdenum, vanadium, iron and manganese . . . Fifty thousand claims have been surveyed for patent

Charles W. Henderson

Supervising Engineer, Denver Section,
Division of Mineral Statistics,
U. S. Bureau of Mines

EVEN in this good roads and automobile era, after combining many adjacent districts of the horseback period, Colorado has 173 separate metal-mining districts. Even today you might wish that some of them be divided, with more local names, if in following a description you found yourself at the wrong end of a district and 10 miles from the mine you had planned to visit. These districts are in 47 counties. And we are not talking of the old mining district of local miner-supervision, formed before the county and territorial governments were created, for those districts lost their legal status when the Territory was formed. We are talking of distinct mineral areas, separated one from the other.

The mineral division of the Supervisor of Surveys, General Land Office, Denver, has 442 different names submitted by patent applicants to cover the 173 districts. The Supervisor of Survey's records show 50,000 separate claims surveyed for patent in Colorado, of which 45,000 have received patents. In addition, there are the claims held only by location on which $100 worth of work must be done annually. Some of these may have had $100 a year spent on them for 30 years. But most of the good claims go to patent, and then pay taxes to the State. I can count on my fingers the number unpatented that have made a large production. Each of the 50,000 claims, for the most part, represents originally a single human being's location and assessment work. Each claim represents at least $500 worth of work before patenting, or a minimum of $25,000,000, and $5 per acre, or $2,500,000, paid to the United States Treasury, not to mention the deputy mineral surveyor's fee of $15 to $25 a day for at least three days on each of 50,000 claims, and not to forget, in these days of "capacity to produce" and "capacity to consume," the hot cakes and bacon that were eaten by the locators and

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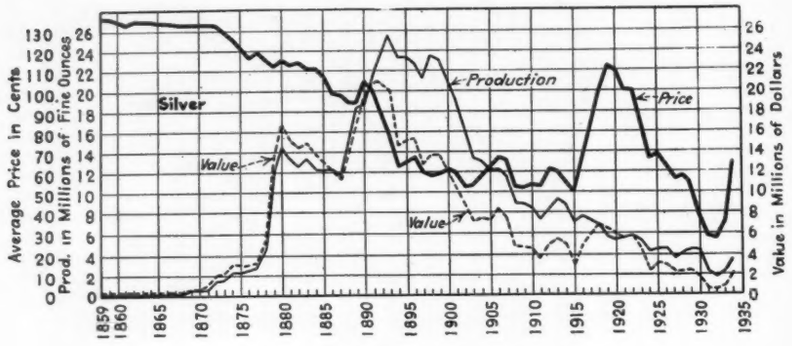
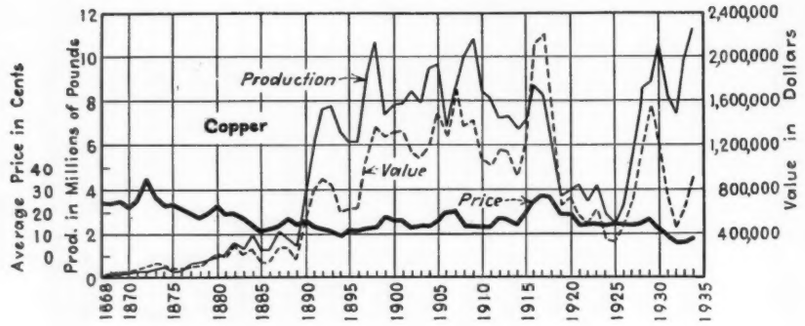
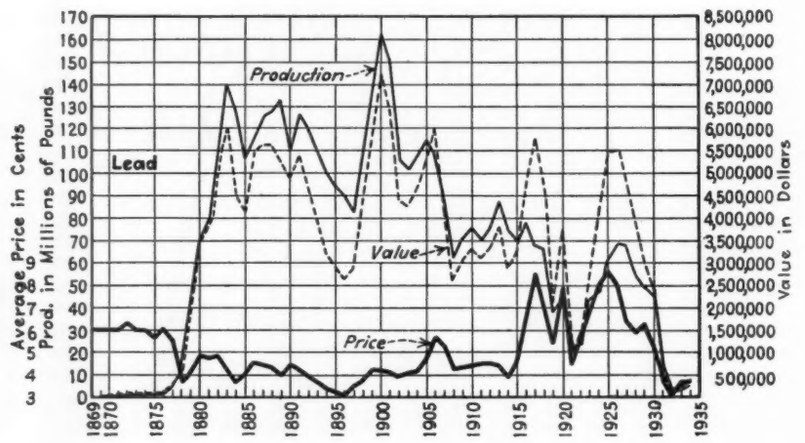






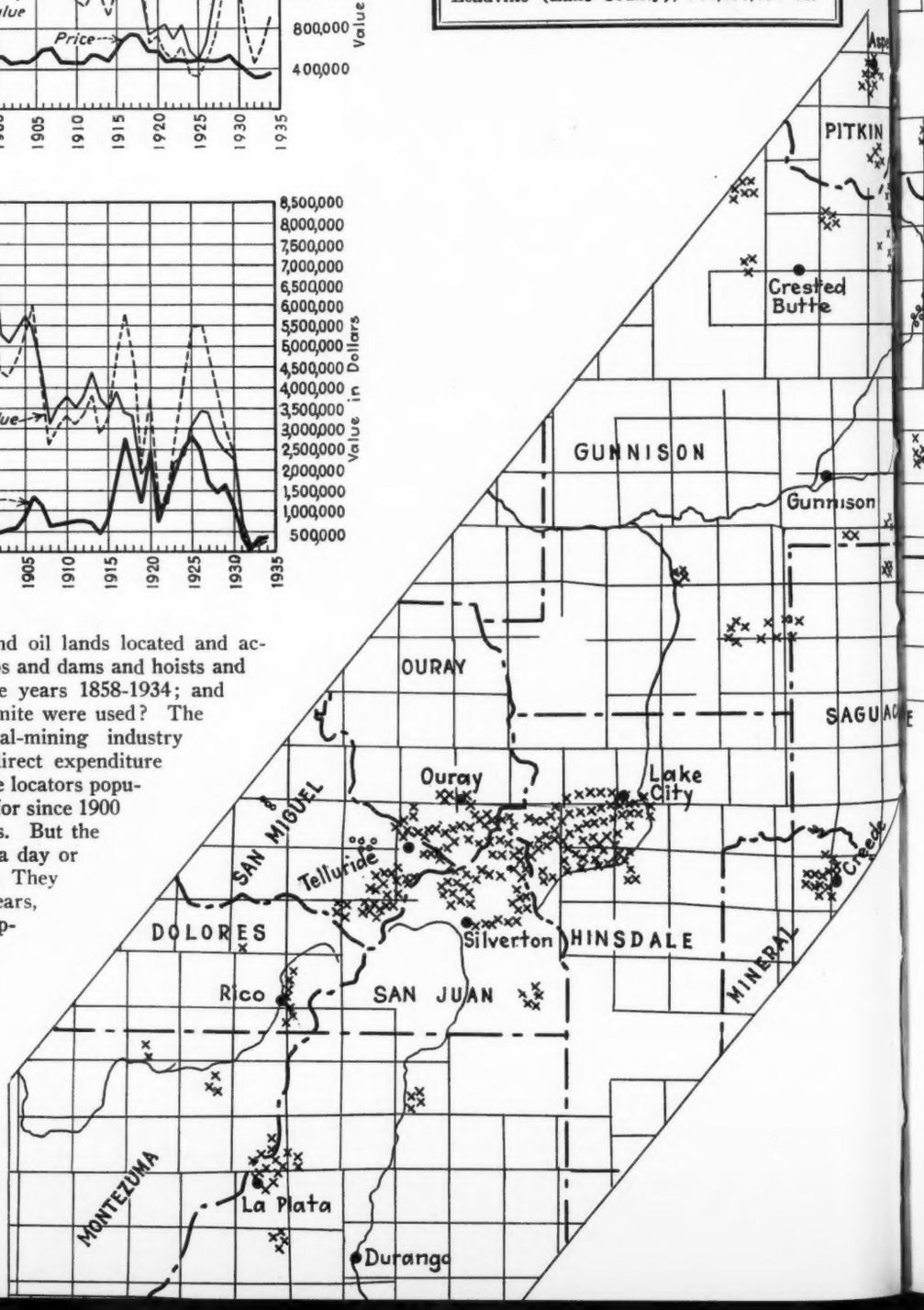
Variety of Metals Produced in Colorado

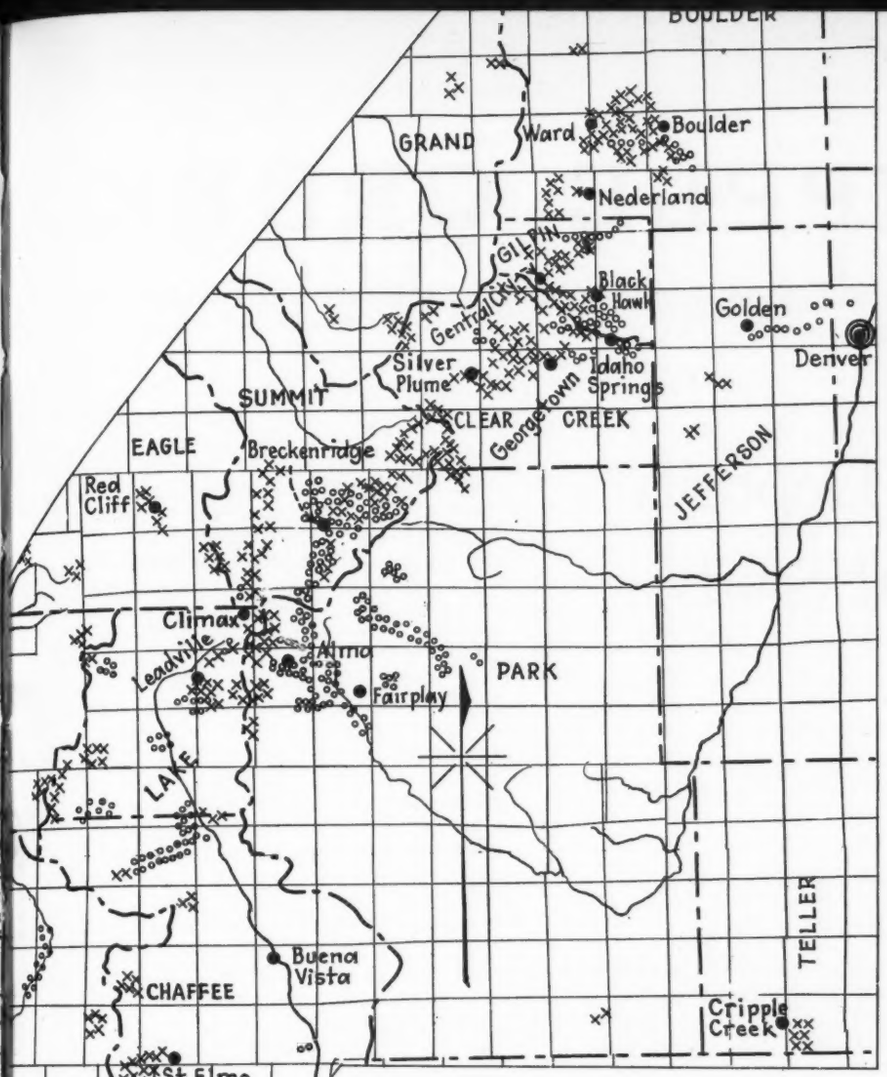
The dollar value of the production of the most important metals found in Colorado, calculated at average yearly prices per unit of sale, 1858-1934, follows:

Gold (35,730,277 oz.) (*a*) (*b*)	$744,437,000
Silver (667,650,042 oz.) (*a*) (*c*)	522,699,000
Copper (341,764,430 lb.) (*a*)	49,141,000
Lead (4,624,877,583 lb.) (*a*)	218,195,000
Zinc (2,234,456,985 lb.) (*a*)	157,188,000
Tungsten	19,700,000
Radium	18,000,000
Molybdenum	27,500,000
Vanadium	7,400,000
Iron	4,000,000
Manganese	4,200,000

(*a*) In terms of recovered metal. (*b*) Cripple Creek district, $361,302,777. (*c*) Leadville (Lake County), 234,630,684 oz.

developers. Omitting the coal and oil lands located and acquired, how many cabins and shops and dams and hoists and portal buildings were built in the years 1858-1934; and how many tons of steel and dynamite were used? The development of Colorado's metal-mining industry represents a huge direct and indirect expenditure of money. Suffice to say that these locators populated the State from 1858 to 1900, for since 1900 there have been few new locations. But the discoveries were not all made in a day or a year, or ten years or twenty years. They cover a preliminary period of 42 years, beginning with the pioneer developments of 1858 to 1875, followed by the dazzling discovery of Leadville in 1877-78, others from 1885-1890, and when things only *seemed* dark to the silver miner, the discovery of the gold camp of Cripple Creek in 1891 and of the silver camp of Creede the same year. Since 1900 the principal discover-





Colorado Mineral Belt
From Boulder to the San Juan

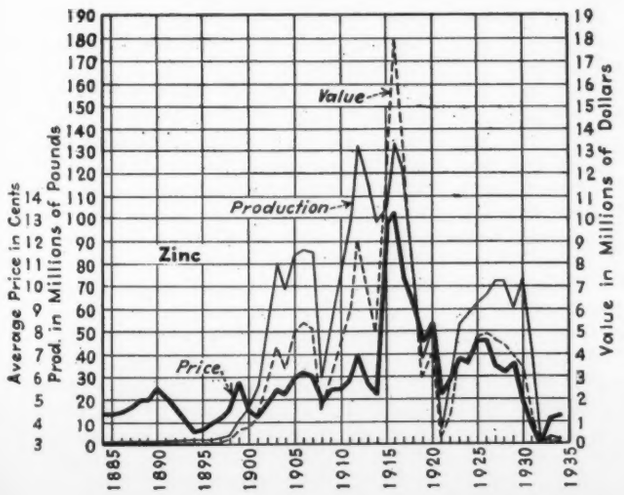
x Lodes o Placers

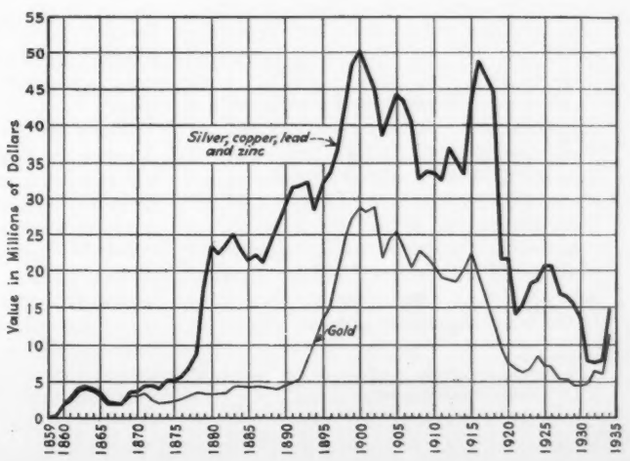
ies have included the uranium-vanadium deposits of the Paradox Valley in 1910, the development in 1918-1934 of the Climax molybdenum deposit, whose outcrop was known in 1890; the discovery of tungsten in 1904, and another vanadium field on East Rifle Creek in 1924.

Subtracting the value of coal and petroleum products ($823,000,000) from the total value of important metals and minerals ($2,597,560,000) leaves $1,774,560,000 gross production by the miners from 1858 to 1934, inclusive. The 100,000,000 tons of the molybdenum deposit at Climax, when and if worked out, will mean a gross production in excess of the gold production, 1858-1934. Three mines in Colorado have large blocked-out ore reserves, one principally of zinc (sphalerite) but with associated copper-silver-gold ores, and two of zinc-lead-silver-copper-gold orebodies. These mines will be worked again when zinc and lead prices rise.

The $35 per ounce gold price (69 per cent increase) has brought about a revival of certain gold-producing areas. In 1934, there was production in 95 districts in 41 counties. At $35 an ounce, new estimates of tonnage available in Colorado will necessarily have to be made—which means an upward estimate. Certain gold ores previously not profitable now become profitable. All zinc-lead ores of Colorado contain some silver, and nearly all gold ores contain silver, so, though Colorado has not hitherto enjoyed a boom when silver was $1 plus per ounce, the present 77c. price, in conjunction with $35 for gold, in certain instances places some very low-grade gold ores, otherwise below profit on gold alone, into a marginal or above marginal grade. The 64c. silver price in 1934 reopened the silver camp of Creede, greatly improved the condition of the silver camp of Aspen, and materially raised the returns on Eagle County's large shipments of copper-silver ore, as well as returns from all other counties in which any silver was produced, either as lead-silver ores or as byproducts of gold.

Charts Show Trends of Production, Price, and Value of Principal Metals





CRIPPLE CREEK

Operators and Lessees, Custom Mill, and Railroad Cooperate

Geology of Ore Deposits Receiving Special Study

Attention directed to large, shallow, low-grade areas—A new drainage tunnel servicing the different subcrater areas is needed

G. F. Loughlin
Geologist in Charge
Section of Metalliferous Deposits
U. S. Geological Survey

WORK in the Cripple Creek district by the United States Geological Survey in cooperation with the State of Colorado and the Colorado Metal Mining Fund has been focussed mainly on questions of downward continuity of ore, and the feasibility of driving a new drainage tunnel 1,000 ft. below the present one. These questions necessarily involve a thorough consideration of geologic structure, and its origin, as well as the character of the ore and the conditions under which it was deposited. Practically no attention has been given to surface mapping, and the reader is referred to Lindgren and Ransome's report[1] for the geologic map and descriptive text. Early results of the recent work were published in 1927,[2] and a more complete report[3] is being published by the Colorado Scientific Society.

Most of the mines in the district are situated in a composite volcano of Miocene age, which has been reduced to a group of hills whose altitudes range from 10,700 down to 9,500 ft. These hills are mostly within the area of the steep-walled volcanic neck, which cuts through Pre-Cambrian granite, gneiss, and schist. The volcano, composed mainly of phonolitic breccia (Fig. 1), was formed by explosive eruptions along a network of master fissures that had resulted from regional compression during the Laramide revolution. Mine workings along the margins of the crater or neck of the volcano show that in most places it narrows downward, and, together with other geologic evidence, justifies the inference that it tapers into several roots or subcraters. The approximate positions of these subcraters and corresponding sources of ore-forming solutions are shown in Fig. 2. The deepest subcraters and the most productive mines are in the southern part of the district. Successive intrusions of latite-phonolite, syenite, phonolite, and alkalic basaltic rocks took place through these subcraters and formed dikes, "flats," and large irregular masses. Subsequent to the basaltic intrusions a local explosive eruption of basaltic breccia took place along the intersection of fissure zones in the central part of the district (Fig. 4), and formed the breccia pipe, called the Cresson "blow-out," that cuts the phonolitic breccia and several kinds of dikes.

Many of the fissure zones and vein formations coincide in direction with the older fissures along which the volcano was developed. They, together with associated minor fissures, may be attributable in minor degree to such local causes as the settling of the breccia within the crater and the upward thrust of intruding lava or of minor explosions. They are, however, attributed mainly to intermittent regional compression and shearing in a northerly direction. This regional activity culminated before the intrusion of phonolite and developed master shear zones in granite at favorably situated corners of the deep subcraters in the southern part of the district. (See Fig. 3.) These shear zones contain the principal mines outside of the crater. During the decline of regional activity the eastern and western parts of the district moved northward with respect to the central part, and the principal vein zones accordingly occupied fissures subjected to tension during this movement. Most of them trend north to northwest in the eastern part and north-northeast to northeast in the western part. Preexisting structures in the northeast part of the district deflected the force more to the northeast, and the vein zones in part follow that general direction. Local conditions have also influenced the distribution and position of veins and oreshoots throughout the district.

The following examples illustrate different local conditions: in the Portland mine, shearing along the contact between latite-phonolite and breccia on the upper levels produced tension cracks in breccia that became richly mineralized, whereas immediately below, where only breccia is present, the ground was not productive; in the Vindicator mine, the distribution of productive fissures was controlled by contact between syenite and breccia; in the Queen mine, productive ground is largely limited to a block in which veins were reopened by tortional stress, while continuations of the veins outside of the block remained tight; at the Elkton mine a bulge in the granite along the south contact of the crater acted as a plunger that produced shear zones in the breccia with intervening tension fractures that became productive; in the Cresson mine the contact of the "blow-out" became productive where it was cut by fissure zones. Shear zones in these and other mines are likely to be productive where slight changes in their strike or dip subjected them to local tension, whereas elsewhere compression kept them too tight to admit ore-forming solutions.

The most persistent vein zones are along (1) the master shear zones in granite, (2) fissures in breccia that are upward extensions of favorably situated reopened prevolcanic fissures, (3) the principal fissure zones that branch from those extensions. The principal disturbance that followed vein deposition

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TODAY

to Give Camp a Maximum of Prosperity

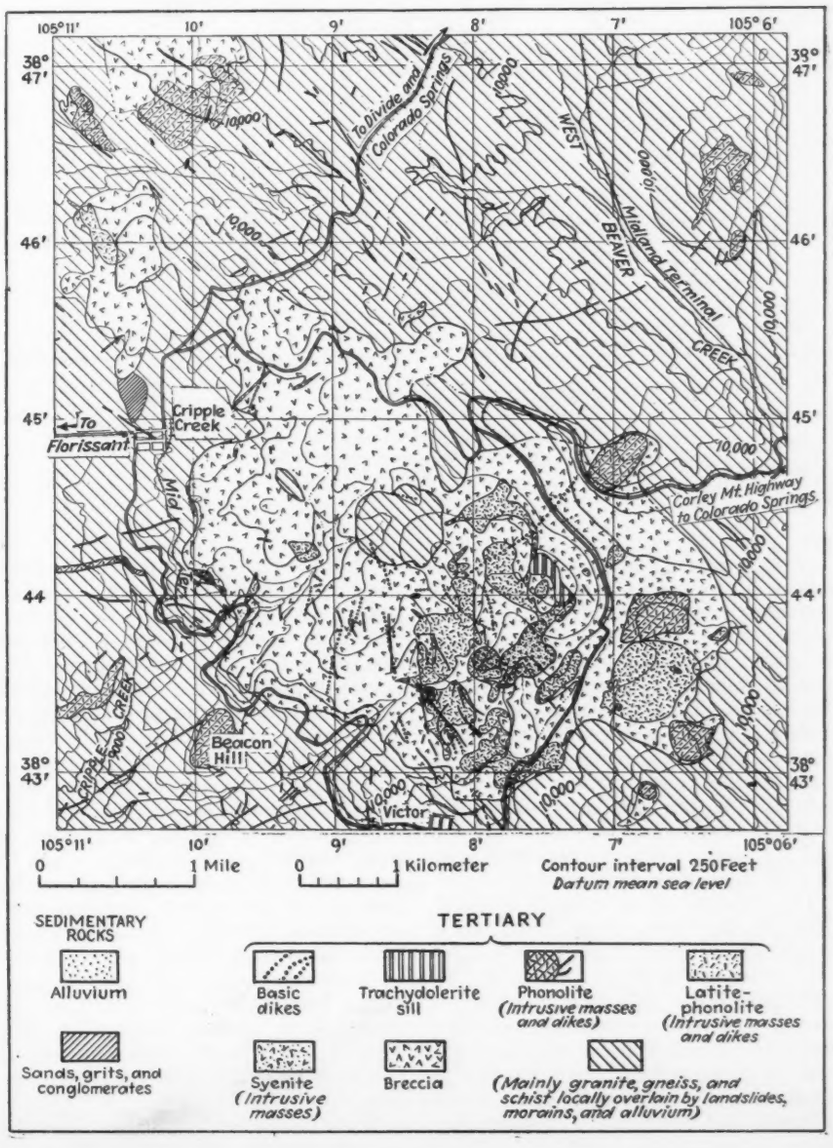
was a prevailingly vertical uplift that produced faults of considerable size in the surrounding country and a few small, post-mineral faults within the district.

During three general stages the mineral deposits were formed. The first stage was characterized mainly by the deposition of jaspery and porous aggregates of quartz and adularia, that have completely or partly replaced granite, and by fine-grained, massive veins of fluorspar and quartz accompanied by some coarsely crystalline pyrite. Some of porous aggregates, commonly referred to as honeycombed or "bug-hole" granite, have been very productive, notably in the upper parts of the Portland, Ajax, and Elkton mines, but others have been of very low grade. The massive fluorspar-quartz veins also have been very productive in a few places, but they are commonly worthless. The productive parts of these first-stage deposits have been reopened and invaded by minerals of the second stage.

Characteristic minerals of the second stage are quartz, fluorspar, fine-grained pyrite, dolomite or ankerite, celestite, roscoelite, zinc blende, galena, tetrahedrite, tellurides of gold, and in some places tellurides of copper and silver. The most common telluride is calaverite which contains gold and very little silver. In some ores whose silver content is sufficient to make them of commercial grade, hessite, a silver telluride, and an unnamed telluride of silver and copper have been found, and in others the silver has been attributed to tetrahedrite. The unnamed telluride of copper and silver identified in ore from the Finley vein in 1930 closely resembles tetrahedrite or "gray copper," and it may be that much of the silver-rich tetrahedrite previously reported in the district has been in reality the same or a closely similar telluride. Association of tellurides with the other minerals is variable, as the tellurides were formed last and in some places after openings had been closed by the deposition of the earlier minerals; indeed, the deposition of gold and other tellurides may be regarded as confined to a substage that closely followed the second stage.

The third stage is represented mainly by openings containing clear to smoky quartz, chalcedony, fine-grained and radiating pyrite crystals, calcite, and locally cinnabar. Some of these late minerals, especially cinnabar, are attributable to rising solutions, but others, especially pyrite and chalcedony, may be attributable to descending water below the oxidized zone. The deposits occur as veins, irregular bodies, and collapse breccias. The veins range from simple fissure fillings less than an inch thick to sheeted zones several feet thick, and in a few places closely spaced veins or sheeted zones connected by minor cross veins form large irregular bodies from 50 to 100 ft. in any dimension. Where the veins coincide with dikes, the sheeted structure common to many of the dikes is likely to be conspicuous, although ore may be confined to a single fracture or a few fractures along the sides or middle of the dikes.

FIG. 1—GEOLOGIC MAP of the Cripple Creek district, indicating principal Tertiary igneous rocks. Adapted from Plate 2 Prof. Paper 54 U. S. Geological Survey



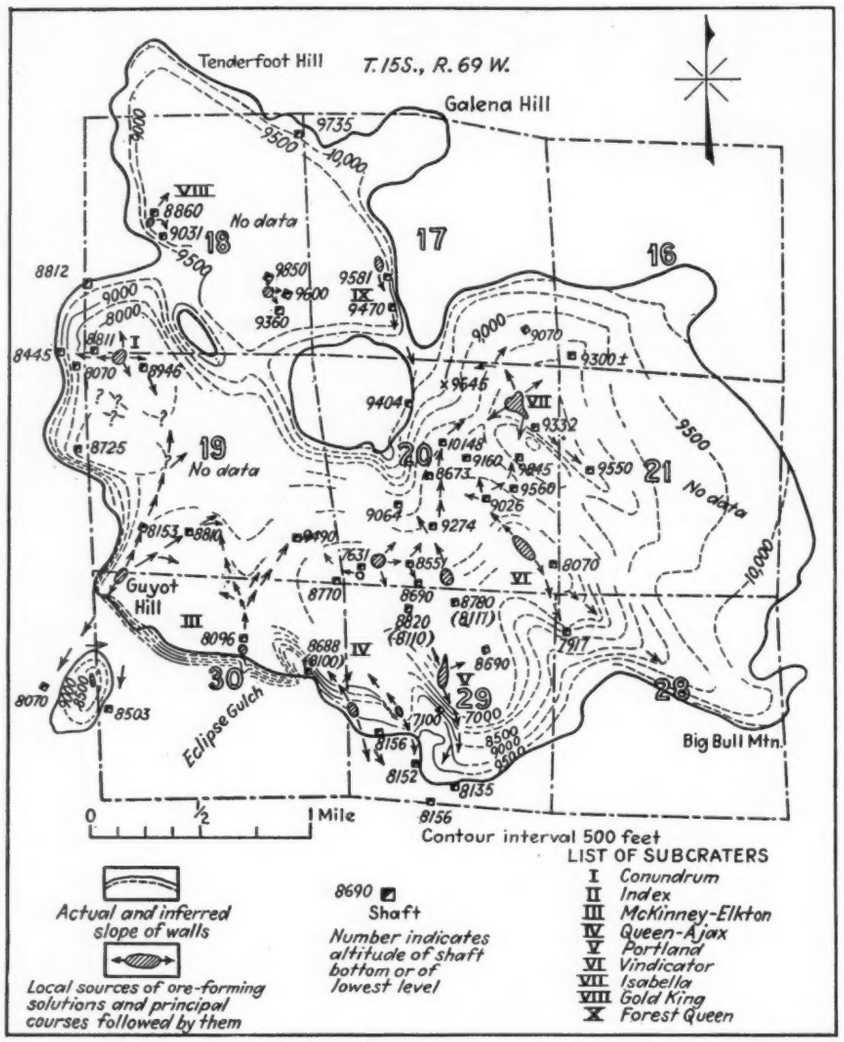


FIG. 2—CRIPPLE CREEK CRATER and subcrater outlined by contour sketch in underground section, also indicating centers or trunk channels where ore-forming solutions rose, and the general directions in which the solutions spread along fissure zones

In some of the more productive veins oreshoots are relatively persistent both horizontally and vertically. The largest veins are sometimes separated by low-grade or barren intervals that appear to coincide with squeezed parts of the fissure. There are step-like interruptions of the veins, or "flats" that separate permeable from impermeable parts of the veins. In the main vein zone of the Portland mine low-grade intervals were penetrated near levels 12 and 23, and another was entered at level 31, the bottom of the mine.

The step-like or *en echelon* arrangement of the veins is an outstanding feature. Koschmann's[4] study of several shallow to moderately deep mines in 1931 showed that this step-like arrangement is more common, both horizontally and vertically, than many operators appear to have realized, and that single oreshoots are prevailingly short. Veins followed any considerable distance beyond oreshoots have proved to be tight and low-grade, and in none of those studied by Koschmann was there a second shoot entirely separated from the first by a barren zone along a single fissure. Some rather closely spaced shoots, commonly regarded as parts of a single vein, proved to be along different veins of a step-like group.

Irregular orebodies occur in shattered ground, which was corroded and honeycombed during the first stage of mineralization. The orebodies vary in form and dimension. Some are roughly lens-shaped and others pipe-like, with or without branches extending along one or more of the fissure zones. A few of them have been found at rather great depth, but more have been found at moderate to shallow depths, in both granite and breccia, where fissuring has been unusually abundant and complex.

The mineralized collapse breccias were formed by excessive corrosion, which reduced shattered ground to rubble early in the first stage. The rubble fragments were coated with minerals of all three stages; but they have been of too low grade to be mined. The exception, however, is the rich cavern or "vug" at level 12 of the Cresson mine. The voids in the breccias were so large and continuous that telluride solutions could move freely through them without being forced to deposit. However, the Cresson "vug" had so small an outlet that stagnation, supersaturation, and deposition were favored and one of the richest oreshoots in the district was formed.

Ore Mined to 3,000 Ft.

Although veins form relatively broad, complex systems at shallow depths, these systems contract downward toward the roots of the subcraters. Ore has been mined to a maximum depth of 3,000 ft., and the general uniformity in mineral composition from the shallowest unoxidized to the deepest exposures gives no indication of an approach to the ultimate depth at which tellurides formed during the period of mineralization. Structural conditions, however, restrict the size, number, and distribution of oreshoots with increasing depth, and, together with the cost of deep exploration, these factors will determine the downward limit of mining.

Where the present bottoms of deep mines are in low-grade ground, and there are reasons for expecting more favorable conditions below, the cost of deeper exploration must be weighed against the expectancy of discovery. In some places ore-forming solutions traveled long distances and even reached shallow ground before finding structural conditions that favored deposition of ore in commercial quantity. The resulting shallow oreshoots are correspondingly isolated, and deep exploration will meet with little or no success.

Shallow Levels Should Be Explored

In addition to deep exploration, there are opportunities for ore discovery by further exploration of the shallower levels, with regard to local structural conditions. Large blocks of shallow, low-grade ground exist in different parts of the district that continue to deserve attention as prospects for large-scale mining, especially in view of the present price of gold. The gold is present along countless small inconspicuous cracks, especially in the intervals between distinct veins, and adequate sampling is required to determine whether the percentage and distribution of waste ground will justify operation.

When the mines were still shallow, groundwater presented a serious prob-

lem. Many mines were pumped and others were drained by tunnels at lower and lower levels. The Roosevelt drainage tunnel, the last to be driven, was started in 1907 and was financed by the principal mining companies. It attained its original objective, but drainage of the district was so slow that extensions were made first to the Elkton and then to the Portland mine, which was reached in 1918. A connection was then made through a 65-ft. raise with the Golden Cycle and Vindicator mines. When this tunnel was started it was expected to drain the mines well below their productive zones, but three mines have already proved productive below the tunnel level, and a few others, though in low-grade ground at tunnel level, would justify deeper development if further drainage were feasible. These conditions led to the proposal of another tunnel that would drain the mines for an additional depth of 1,000 ft. Driving such a tunnel would necessarily be speculative, but in so far as an estimate of ore reserves below the present tunnel can be made, the venture deserves consideration.

Geologic conditions are generally favorable for the driving of the proposed deep drainage tunnel. The groundwater, however, tends to become increasingly isolated with depth in basins that correspond to the subcraters, and any tunnel, to effect adequate drainage of the district. should have branches reaching to the different subcraters. A consideration of geologic and groundwater conditions as well as the most promising deep ore reserves favors a tunnel that would extend from Marigold, about 6 miles south-southwest of the district, to the Granite and Portland mines, with a northward extension towards the Cresson mine, which is in the same basin as the Granite mine. A direct extension could be made from the Portland to the Vindicator mine, and a long branch from the Cresson extension could be driven to drain mines in the southwestern part of the district.

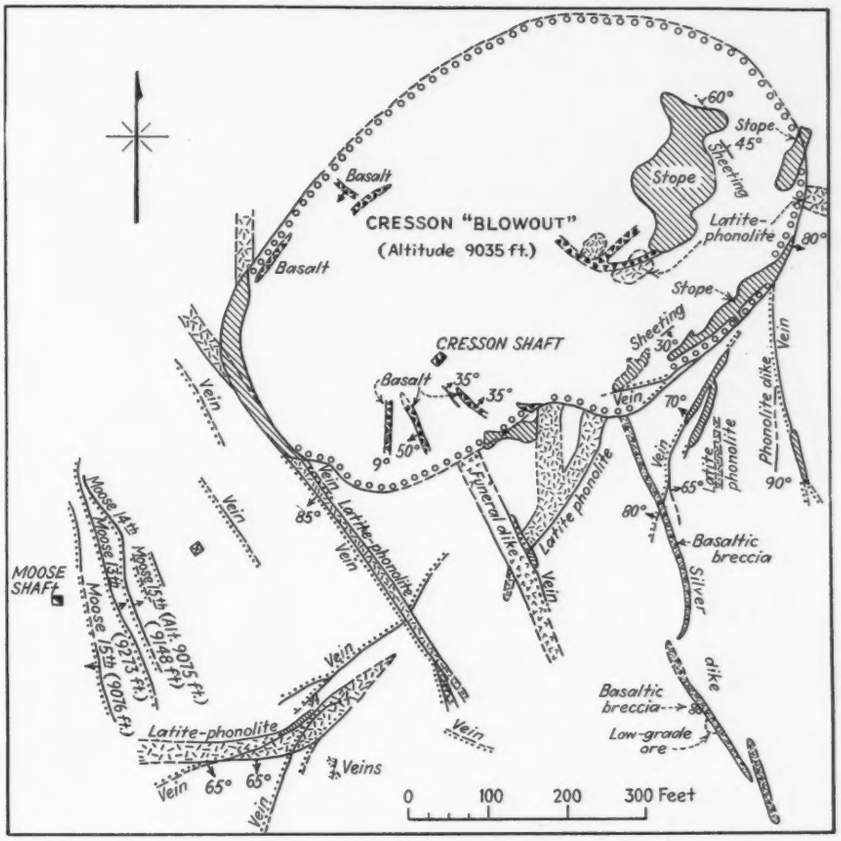


FIG. 4—CRESSON MINE MAP showing relations of "blow-out," which is itself cut by local basaltic dikes, to breccia and dikes of main crater and to veins and irregular orebodies

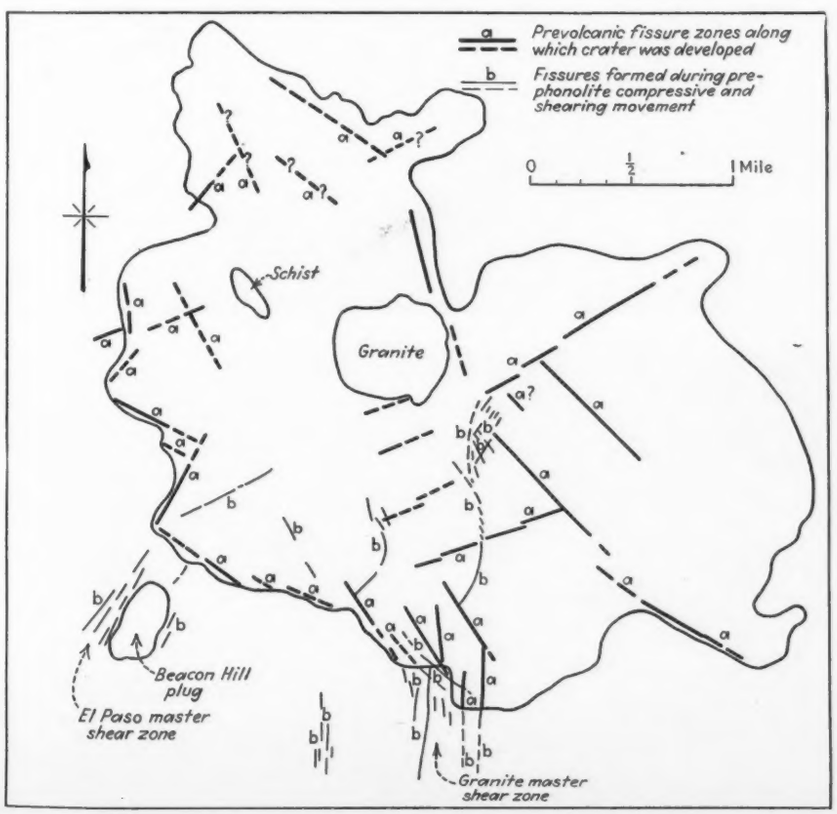

Prevolcanic fissure zones along which crater was developed
Fissures formed during pre-phonolite compressive and shearing movement
0 ½ Mile
Schist
Granite
Beacon Hill plug
El Paso master shear zone
Granite master shear zone

FIG. 3—FISSURE ZONES of pre-volcanic origin that controlled development of the Cripple Creek crater; also principal fissures in and adjoining crater, developed during subsequent pre-phonolithic compression

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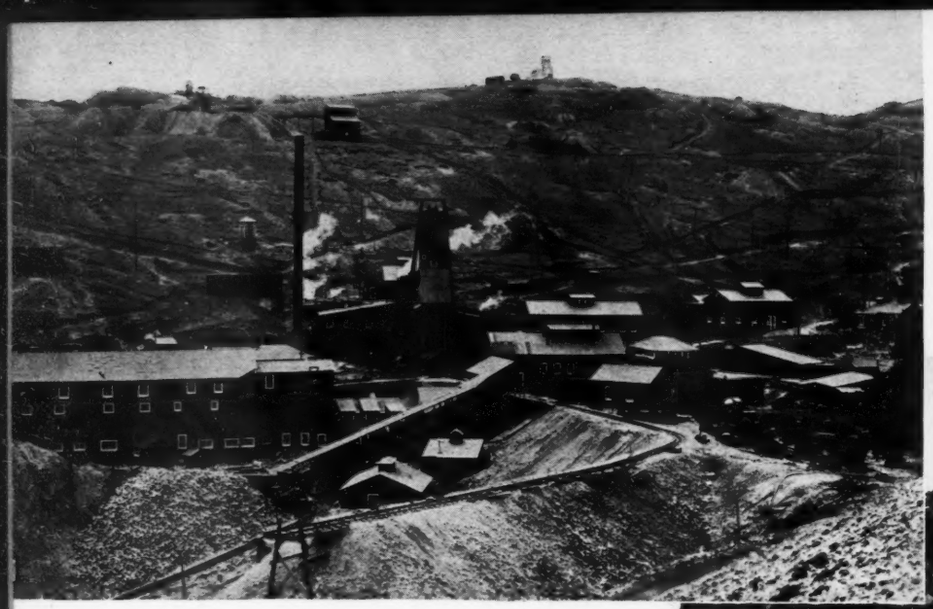
[1]Lindgren, Waldemar, and Ransome, F. L.: U. S. Geological Survey Professional Paper 54, 1906.

[2]Loughlin, G. F.: "Ore at Deep Levels in the Cripple Creek District, Colorado." A. I.M.E. Technical Paper 13, 1927.

[3]Loughlin, G. F., and Koschmann, A. H.: "Geology and Ore Deposits of the Cripple Creek District." Proceedings Colorado Scientific Society, 1935 (in press).

[4]Loughlin, G. F., and Koschmann, A. H. *Op. cit.* (In press).



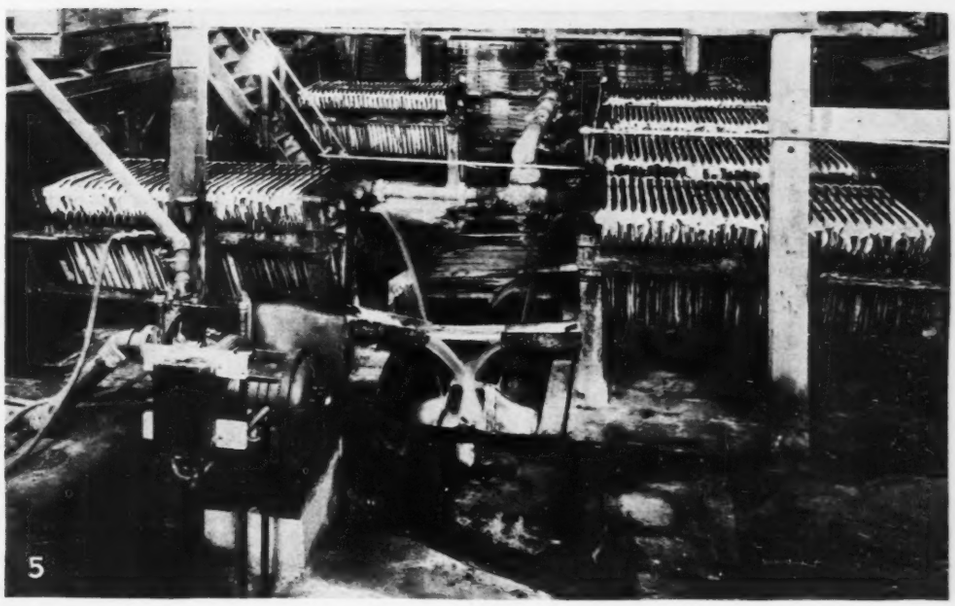
IN AND AROUND CRIPPLE CREEK

1 **SHAFT HOUSE and surface plant of Cresson Consolidated Gold Mining & Milling Company, on Raven Hill—one of the principal operators of the district**

2 **A TRAINLOAD of Cripple Creek ore, coming down Ute Pass to the Golden Cycle mill at Colorado Springs**

3 **CRIPPLE CREEK, the town, as seen from Gold Hill. Its elevation is 10,000 ft. above sea level and its population 3,000. Mount Pisgah is at the left**

4 VICTOR, neighbor of Cripple Creek, and the south slope of Battle Mountain. On the skyline in the center, the Portland mine, and, left of this, the Ajax



5 PRECIPITATION PRESSES in the cyanide plant at the Golden Cycle mill

6 THE GOLDEN CYCLE plant at Colorado Springs. Here all Cripple Creek ore is treated, amounting to 80 to 85 per cent of the daily tonnage. The mill has concentration, roasting and cyanidation facilities

Mine Practice Closely Linked With Leasing System

Latter has proved advantageous where supervised . . . Shrinkage stoping generally used . . . Sampling, breaking, and sorting of particular importance . . . Large reserves unusual

A. H. Bebee
Superintendent
Cresson Mine

Walter R. Vidler
Superintendent
Elkton Mine

GOLD was discovered in Cripple Creek in 1891, and, from the start, leasing of the mines played an important part in developments. Inasmuch as possibly 75 per cent of the work is being done by lessees, a review of the leasing systems and the policies in vogue is given, as many of the practices which may seem peculiar to the district are influenced by the leasing policies.

The mining leases granted have been in general standardized as to observance of proper and safe mining practices. Royalties are fairly uniform. On straight lease agreement the graded royalties are as follows: 10 per cent, up to $15 per ton value; 15 per cent, up to $20; 20 per cent, up to $30; 25 per cent, up to $50; 30 per cent, up to $100; 35 per cent, over $100. Royalties are computed on the net ore returns, after subtracting the freight and treatment charges.

The Cripple Creek "split-check" lease system, which originated at the Portland mine in 1913, is practiced at the larger mines and properties that have supervisory organizations or managers on the ground. The methods and policies applying at the Cresson mine are generally followed elsewhere in the camp and are as follows:

Leases are given for one year, but work may be stopped at the discretion of the management. Leasing is carried on usually where ore has been left in pillars or along old stope walls, but occasionally in other areas where the lessee believes undeveloped ore exists. Lease blocks are of different sizes, but generally 200 ft. square and one level high. Lessees are required to put in at least 50 man-shifts a month. They are subject to all company rules regarding safety and sanitation. Pillars may be removed only with the management's permission. The company reserves complete authority over the work, but such authority is exercised only in case of incompetence or dangerous or wasteful practices.

The company supplies compressed air, equipment (excluding only drills), explosives, and other supplies, and hoisting service, and transports the ore from the ore house to the railroad and loads it. A charge of 10c. per ton is made for transporting the ore on the aërial tram and loading it into cars. The lessee provides only the labor, including miners, trammers, and ore sorters (in practice he usually is permitted to use such old machines as the company has available, free of charge) and pays his own compensation insurance. The company and the lessee divide equally the net returns (gross value less freight and treatment charges), less 1 per cent of the gross value as the lessee's share of taxes, and less the handling and loading charge noted in the foregoing.

Under this system men with little capital are enabled to undertake leasing, and as they can lose only their labor and are not faced with cash expenditure for each foot or ton of ground broken, a relatively large amount of prospecting is done and all favorable areas are searched thoroughly before being abandoned. This often leads to the discovery of ore beyond or below the lease boundaries that justifies company operation. The management keeps closely in touch with lease work and avoids wasteful use of supplies by issuing only such material as appears to be necessary.

A combination of both methods is sometimes employed, whereby the owner of a large property leases on a graded royalty basis to a reliable leasing company and the latter in turn subleases on the split-check system. In such cases the owner's royalty is first deducted and then the leasing company and the sublessee split or divide the ore returns equally. In the latter case, the owners generally allow a lower royalty to competent operators who are managing split-check lease operation through sublessees.

Much has been written in the past about the drawbacks and advantages of leasing. In Cripple Creek practice, there is no doubt of the advantages of leasing, provided efficient supervision of lessee operation is constantly enforced; otherwise the drawbacks soon become evident and the mining property suffers in many ways. Experience has shown that where lessee operations have been closely and strictly supervised, the work has been successful. In many cases the supervised lessee operations alone have perpetuated profitable operation. In the absence of constant supervision, lessee operations have been not only of doubtful value to mine owners but destructive out of all proportions to the amount of royalty produced.

The lode fissures or "veins" of the district are exceedingly inconspicuous; there are no bold outcrops and the underground veins may occur more as streaks or as a series of parallel fractures comprising a sheeted zone. Most of the veins have a vertical steep dip, although many important orebodies have been mined from fairly thick flat-dipping veins. Large lenticular type orebodies are also found in the granite rim close to the breccia contact. In the breccia or granite both the ore and the walls, as a rule, stand well and little timbering is necessary for support. Square-set timbering, although largely employed in mining large orebodies in the past, is now rarely used.

Values in Lenticular Oreshoots Erratic

In the lenticular or chimney-type oreshoots the distribution of values within the orebodies is erratic; small and large horses of waste are encountered, and the walls and trend of the ore are so irregular that seldom can a stope layout be designed in advance of stoping. Stoping limits usually are determined by assay. In shrinkage, backs 60 ft. or more wide stand safely and old empty stopes stand open indefinitely without caving.

A characteristic of most of the Cripple Creek ore deposits is the amount and character of waste that must be handled with the ore. Many of the large orebodies are represented in reality by sheeted zones wherein the gold values were concentrated along a multitude of seams or crevices and the volume of rock itself between streaks or enriched seams is of no value. The

peculiar character of most of the ores is such that there is practically no difference between specific gravity of ore and waste, and when the ore is blasted there is a tendency for the valuable minerals from the seams and streaks to be reduced to a fine light powder and to comprise the lighter part of the mass of broken rock. Mechanical concentration by ordinary specific gravity methods is therefore difficult, and simple dry screening methods, combined with hand sorting, have, in practical operations, proved more efficient.

The problem of mining the aforementioned types of orebodies to the best advantage is to drill and break the ore in such fashion as to convert the ore seams and mineralized streaks into fines so far as possible, without undue breaking of the intervening rock and adjacent wall rock. The general practice is to drill holes in ore streaks and blast these heavily to secure a maximum amount of shattering of the minerals in the veins and streaks, and to blast adjacent wall rock or intervening rock streaks lightly, to keep the waste rock as large as possible.

Lessees frequently take exceptional care in selective drilling and blasting of the ore to secure as great a concentration of values into fines or "screenings," and to a degree not always practical in company operations conducted by day-pay miners.

Prospecting, Exploration, and Sampling.—Prospecting and exploration are done by drifting and raising. Prospect headings are frequently run from stopes. Few "ore guides" are recognized, although the general association of basalt dikes with the orebodies is used as a guide in prospecting new country. As a general practice, the ore cannot safely be projected far ahead of actual exposures. Exploration workings follow the ore as closely as possible; hence drifts are exceedingly crooked. Intersections of the dikes with veins or with strongly sheeted zones are considered favorably.

A great amount of sampling is done to guide both exploration workings and stoping, as well as to control the grade of mineral hoisted for ore and to serve as a check upon sorting operations. As a general practice, all faces, whether in ore or waste, are sampled after each round, by taking at least two cuts across them. Moreover, two or more grab samples are taken from the muck pile. At the larger mines, this work is done as part of the daily routine of the foreman and shift bosses, and most lessees follow the same practice. Samples thus taken early in the morning are assayed during the day, and the results are thus made available before the end of the shift.

According to the experience of many operators, diamond drilling is considered unreliable for estimating the grade of ore or even in locating ore deposits. The nature of the narrow ore streaks makes core recovery difficult from the sheeted breccia, and the porous nature of the country rock makes sludge sample recovery difficult by some methods. Results from diamond drilling of the larger lenticular types of orebodies have also been disappointing, probably due to the vuggy, porous texture of the ore.

Seldom are any estimates made of either broken ore or probable ore in place, and as a general rule, even in the most important producing mines, any exceptionally large tonnage of broken ore reserves are seldom found. The ore has always been mined out as rapidly as possible, as soon as found. The Elkton mine, as an example, has produced over $13,726,205 (Dec. 31, 1921), and probably at no time in the history of the mine could there have been any definite estimates of proved minable ore with value in excess of $250,000,

Air Compression—The smaller mines are supplied with air by the Teller County Air Company, which has two central distributing or compressing plants in the district. Small mines and leasers buy the air they use from this company and pay for it by the machine shift, or by the rate of $2.75 per machine run in each shift. The company maintains air lines all over the district, with large receivers placed at various points. The larger mines manufacture their own air with large, modern-type, electrically driven, and highly efficient air compressors.

Development—Though numerous tunnels have been driven in the past, major developments are conducted by means of two- or three-compartment shafts. Skips of various sizes are used at most mines, with a few still employing cages. Buckets are still used at the small mines. Levels are generally spaced at intervals of 100 ft. All types of air-drill equipment are represented in use throughout the camp. Drifting machines used are commonly wet Leyner type using, generally, 1⅛-in. hollow round steel, although a few mounted jackhammer type drills are sometimes used by lessees.

In drifting and crosscutting, from 12 to 22 holes are drilled, depending on the nature of the ground. The Leyner cut is generally used, although a "burn-cut" round is sometimes used. A "burn cut" generally requires more holes, with all holes drilled parallel and straight in, with four or five cut holes centering around a "blank hole" which is drilled a few inches deeper than the remainder of the round. This center hole is not loaded and the cut holes are laid out to break the intervening ground to it when the round is blasted. The "burn cut" is more frequently used when shooting close to timber or in holing through workings, where a small size or easily controlled size of opening is desired. An average of 3 ft. advance is made with each round drilled in crosscut drifts, although advances in one round have been made up to 10 ft. by using the "burn cut." Blasting is done principally with 40 per cent semi-gelatin powder. Stemming is not used. All mucking is done by hand, loading into 1,600-cu.ft., box-type, end-dump cars. As a general rule, only one mucker is employed to clean out drift rounds and lay track as required.

Stoping—In the lenticular ore deposits, the shrinkage method of stoping is generally used because of the excellent walls and back, the fair width of the stopes, and the impossibility of using any systematic open stope method requiring advance development, such as sublevel stoping, owing to the irregular nature of the orebodies. Stopes are worked through manways spaced as convenient or permitted by existing drifts and crosscuts, and not at regular intervals. The average spacing of drawing chutes under the larger shrinkage stopes is about 25 ft. Connections are made to upper levels from the stopes when needed for ventilation or to facilitate the handling of supplies.

The shrinkage method is also employed generally in the narrow vein stopes. A variant of shrinkage stoping has been developed by lessees, where it is desired to ship more ore from a stope than shrinkage will permit, and also to allow a two- or three-car lot storage space to be provided that can be pulled and trammed independently from below ore fill on which mining and drilling operations are conducted. The stope is started and carried up as is usual, with shrinkage stope methods, with stull and lacing partition for a manway on one or both ends of stope. After the stope is up 40 or 50 ft., a floor of heavy lagging is carried from the manway lacing on stulls for a length of 25 to 30 ft. From the end of this first floor and at an elevation about 5 ft. lower, a second floor of lagging is constructed. Timbering is done working on the ore fill. A simple control chute is constructed between the ends of upper floor and lower floor. A series of similar floors and control chutes are constructed for the length of the stope, but usually one or two will suffice for the length of stope mined under this system.

Stoping then proceeds, working on ore fill resting on floors. The ore fill below is then pulled out entirely and shipped. Later, as stoping proceeds, the shrinkage is drawn off into empty storage portion of stope until one or more shipments are accumulated. Sometimes the lessee may have to wait for several days before ore-house facilities are available and the ore storage provided below shrinkage control chutes permits mining to continue. Drilling in large stopes is done chiefly with self-rotating stopers, using 1-in. hollow hexagon steel. Lessee operators use

all types of machine drills, with a great many dry machines using 1-in. cruciform steel still in use. Holes are drilled 4 to 8 ft. deep and 18 in. to 4 ft. apart.

In the narrow stopes, stulls and lacing are used for manway partitions. In the large, wide stopes, single-compartment raises, solid cribbed, with half lapped round 4- to 6-in. cribbing, are used. Chutes are of timber, 3 ft. wide, ruggedly built, with heavy plank control boards. Usually, rock pillars are left over the drift between chutes. In a few instances in narrow orebodies or where the orebody is believed to be of small vertical extent, the broken ore is carried on stulls over the drift. An effort is made to reduce all boulders in stopes to 12 in. or smaller before they are buried or drawn into the muck. Probably only 1 or 2 per cent of the rock broken requires secondary blasting, and perhaps 5 per cent is broken by hammering.

Tramming and Hoisting—All tramming from stopes is done by hand. Most company ore is trammed by men working on contract, who are paid according to the number of skiploads or mine cars trammed. Pockets are used at some of the larger mines. Nearly all of the mines, large and small, use electric powered hoists as well as electrically driven air compressors.

Ventilation and Drainage—The deeper mines are ventilated by natural air currents coming through the drainage tunnel and connections to adjoining mines, and the smaller mines depend on natural ventilation. Small motor-driven fans and flexible ventilating pipe are sometimes used to remove smoke and gas from blasting in dead ends. A ventilation door is frequently installed in a drift leading to a gassy section of the mine and work is carried on there under a slight pressure, created by a motor-driven fan, which is enough to hold the gas back in the rock.

Practically all of the mine workings in the camp are dry above the deep drainage tunnel. Altitudes of the various shaft collars range from 9,500 to 10,700 ft. above sea level, and the drainage tunnel elevation is around 8,100 ft. A few of the mines have tried working below the tunnel level, but the pumping expense is too great, as a rule, to permit profitable operations. A deeper drainage tunnel is the proposed solution to the water problem.

Transport and Milling—Despite the mountainous nature of the camp, a network of railway spur lines and switches serve the entire camp, with some of the mine ore-house bins directly on the railroad and nearly all mines having very short hauls to loading docks where trucks dump ore direct into railroad gondola cars. The ore is milled at the Golden Cycle mill at Colorado Springs.

Railroad facilities and rates for hauling ore shipments, combined with the custom ore rates of the Golden Cycle mill, have not only permitted but encouraged the multitude of small and medium-sized operations throughout the camp. Probably at no time the past ten years has any one mine had sufficient ore proved to have justified the erection of even a small mill, yet in the aggregate the tonnage of ore shipped daily from the district and handled by the Golden Cycle mill runs considerably over 1,500.

Ore Sorting and Classification—Practically all of the ore is recovered and seldom is any left in pillars. Dilution by coarse waste rock is high and varies greatly in various types of deposits, and the percentage of waste to ore necessarily mined together is high. As a general practice, the natural tendency of friable gold minerals to concentrate into fines or screenings is taken advantage of, both in the mining and in the ore-house classification methods. The first step for making a rough classification occurs in breaking the ore in the stopes, also by blasting the streaks harder and endeavoring to keep intervening wall rocks in larger pieces. With many ores, the difference in specific gravity between the valuable and worthless minerals is a great aid in concentrating cheaply by mechanical means, but with Cripple Creek ores this difference is not dependable, for a very high percentage of the valuable material is found in the light-weight fines or "screenings," and yet there remains considerable coarse ore mixed with coarse waste rock in the ore mass. Hand sorting, combined with dry screening methods, has been the solution.

At the Cresson mine, between 35 and 40 per cent of all ore hoisted is discarded by sorting in the surface ore house. Very little sorting is done underground. In some cases as much as 85 per cent of ore material hoisted has been discarded as waste.

Mining Costs, Cresson Mine

	1931	1932	1933	1934
Company ore, net tons	34,674	35,373	33,985	49,407
Lessee ore, net tons	20,073	26,541	30,063	42,571
Total net tons	54,747	61,914	64,048	91,978
Costs, per ton:				
Shift bosses	$0.20	$0.16	$0.15	$0.13
Breaking	1.78	1.57	1.40	1.33
Tramming	0.63	0.52	0.46	0.33
Timbering	0.25	0.26	0.23	0.19
Hoisting	0.56	0.47	0.46	0.42
Blacksmith	0.18	0.15	0.15	0.15
Assay Office	0.10	0.08	0.08	0.07
General Office	0.02	0.03	0.03	0.02
Machinist	0.24	0.22	0.21	0.18
Sorting and Loading	0.50	0.40	0.40	0.34
General Operation	0.29	0.18	0.20	0.20
Taxes	0.13	0.09	0.10	0.08
Compensation	0.13	0.11	0.10	0.11
Orehouse	0.13	0.12	0.27	.....
Total	$5.14	$4.24	$4.16	$3.55

As a general practice throughout the camp, the sorting and classification are done in surface ore houses, the mixed ore material being dumped over wire screens protected by light grizzly bars. Various screens are used, from ½- up to 2-in. mesh, but the 1-in. mesh screen is most generally used. The percentage of screenings saved in proportion to coarse ore saved varies, but generally is within range of one part to one of coarse to one part fines to two parts of coarse.

The screenings are held in separate bins and shipped separately and represent the highest-grade ore, and generally are two or three times more valuable than the same tonnage of coarse ore shipped. The over-size material goes into storage bin feeding by gravity onto heavy steel sorting tables, where experienced ore sorters pick ore into bins and shove waste into tram cars for conveyance to the waste dump. The number of ore bins with sorting tables varies with the size of the property.

At the Cresson, the company ore is sorted in one section of the ore house and lessees' ore in the other. Provision is made for handling the production for sixteen sets of lessees at a time. Lessees' ore is dumped over grizzlies, set 4 in. apart, under which is a double woven-wire screen with 1½- and 7-in. square openings. The screen oversize goes to a 30-ton intermediate pocket and the undersize directly to a tramway loading pocket. Waste is thrown into small mine cars, which are hand-trammed to outside waste bins, whence the waste is trammed in 2-ton electric, side-dump waste cars to the waste dump.

The company ore is dumped into a hopper, then passed through two revolving wet trommels, 4 ft. in diameter and 16 ft. long, with maximum loading openings 1½ in. in diameter. Undersize goes to a 75-ton tramway loading pocket and oversize onto a rubber picking belt 24 in. wide and about 30 ft. long, at which five or six sorters can work. A normal crew on a belt is four. The ore is picked out and dropped into chutes or openings beside the belt; the waste drops from the end of the belt into a small pocket, whence it is handled similarly to the lessees' waste. The two trommels and two picking belts are arranged in parallel.

Costs—Actual costs of mining are relatively high, due to the amount and character of waste that must be handled with the ore. Few figures are available, as most of the smaller mines have no cost-accounting records.

At the Elkton mine, mining costs per ton mined, hoisted, sorted, and loaded on railroad cars vary widely with different stopes, with a range from $2.29 per ton up to $4.41 per ton, including administrative and general expense.

The accompanying table shows the operating costs at the Cresson mine, based on dry tons of both company and

lessee ore that is shipped to the mill.

The costs in the accompanying table, though based on the total of company and lessee ore, take no account of lessee labor, lessee compensation payments, or other expenditures. As the labor by lessees in breaking, tramming, and ore sorting comprises 35 to 40 per cent of the total labor on surface and underground, the costs are misleading to that extent. As lessees received their pay in the form of half the net returns, this amount may be fairly added to the costs in the table.

In 1931, payments to lessees, divided by the total of lessee and company ore (excluding dump ore), amounted to $1.42 per ton, and in 1932 to $1.59. Added to the figures in the table, these would increase the total mining costs for 1931 and 1932 to $6.56 and $5.83 respectively.

At the Cresson, the amount of explosives for the year 1932 was 3.7 lb. per ton of ore shipped, 2.3 lb. per ton of ore hoisted, and 1.9 lb. per ton of ore and waste hoisted; that is, all material broken, assuming equal reserves of broken ore in stopes at the beginning and end of the year. The cost of dynamite was $0.51 per ton of ore shipped, $0.32 per ton of ore hoisted, and $0.27 per ton of ore and waste hoisted. Explosives used were about three-fourths Gelex No. 2, and a Du Pont bulk powder of 45 per cent strength, averaging 120 sticks per 50-lb. case, and one-fourth Du Pont Special Gelatin of 40 per cent strength, an ammonia-gelatin dynamite. The costs noted included freight to the point of delivery at the lower end of the mine aërial tramway, but no further handling charge. Fuse, which was used at the rate of about 3,500 ft. daily, and caps, at the rate of about 500 per day, added an estimated amount of $0.14 per ton shipped, to cost of explosives.

The cost of timber for chutes, stope manways, and minor miscellaneous uses was about $400 monthly, or, roughly, $0.08 per ton shipped, not including any cutting, framing, or handling charge. The sawed timber costs about $27.50 per 1,000 bd.ft., but as most of the timber used was purchased in round sticks, the average cost per 1,000 bd.ft. was probably less than $25. Timber consumption per ton was not more than 3 or 4 bd.ft.

Electric power for air compression averaged about 10 kw.-hr. per ton of material hoisted—that is, broken—and about 20 kw.-hr. per ton of ore shipped.

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Golden Cycle Mill Serves Cripple Creek Well

Custom plant offers roasting, cyanidation, and concentrating facilities—Now handles complex gold-silver ores from other districts also

General rule as regards recovery is: Keep as much gold in the plant as possible, to ship to the Mint, and send as much lead, copper, and silver as possible to the smelter

Max W. Bowen

Superintendent, Flotation Unit
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OPERATING CONTINUOUSLY since 1907, the mill of the Golden Cycle Corporation, at Colorado Springs, has been a custom plant from the start. Originally, its capacity was 37,000 tons per month when treating "oxidized siliceous" ores by roasting and cyanidation, and 32,000 tons when treating what are locally called "basic" ores. In 1929, a concentrating unit was added for treating complex ores and gold and silver ores from elsewhere than the Cripple Creek district, as well as the low-grade ores from the latter. In 1934-1935, the combined capacity of the two plants has been raised to approximately 1,500 tons per 24 hours, the roasting-cyanidation plant handling 1,000 to 1,050 tons of original ore plus the concentrates from the concentrator, which amount to 25 to 50 tons per 24 hours, and the latter plant's tailings, which run about 425 to 450 tons per 24 hours. The operation of the roasting-cyanidation plant was described in United States Bureau of Mines Information Circular 6739, published in July, 1933. The details there given are not repeated in the following save where changes have since taken place or where repetition is necessary to make the account continuous.

Of the total tonnage treated, 80 to 85 per cent comes from the Cripple Creek district. This consists primarily of sulpho-telluride gold ores, carrying a small amount of silver and negligible quantities of base metals, such as lead, copper, zinc, arsenic, antimony, and mercury. The remaining 15 to 20 per cent comes largely from the well-known districts of Clear Creek and Gilpin counties, and from the Alma, Leadville, and Boulder districts, with occasional shipments from a few other districts of Colorado, New Mexico, and Wyoming.

Having to do only with custom ores, the plant has a complete sampling unit. Ores are treated either by roasting followed by cyanidation of the roasted product, or by concentration and cyanidation of the tailings after dewatering. The first method is used on the average grade of Cripple Creek ores, with which are mixed all iron concentrates either from the concentration plant or from elsewhere. The ore thus treated is here referred to as "roaster" ore. The second method is used on low-grade Cripple Creek ores and on nearly all ores received from other districts. The lead and copper concentrates, or the latter alone, obtained from the treatment of the complex ores are filtered, dried, and shipped to Leadville. Iron concentrates from all ores are filtered and mixed with "roaster" ore as it goes to the secondary crushing plant. The ore treated by this second method will be referred to as "concentrator" ore.

The flowsheet of the secondary crushing plant is shown in Fig. 1-A. The two Symons cone crushers used will handle 75 tons per hour, taking 3½- to 4-in. maximum feed and reducing it to 4 mesh.

Up to this point—through the secondary crushing plant—the "roaster" ore and the "concentrator" ore have traveled (separately) the same route. From here on, they follow different flowsheets, the "roaster" ore following that given in Fig. 2 and the "concentrator" ore that in Figs. 3 or 4.

The concentrates included in the

"roaster" ore are added to the crude ore ahead of the stationary screen in the secondary crushing plant (Fig. 1-A), insuring thorough mixing before entering the roasters.

Cripple Creek ores received are either "siliceous" or "basic," the former coming from the upper oxidized and leached zones and the latter from the level below these zones. The former can be readily crushed, ground, or roasted, whereas the latter are denser and harder and cause more trouble in crushing, grinding, and roasting.

The Hum-mer screen undersize is roasted in eight Edwards duplex roasting furnaces. The furnaces are 115 ft. long by 13 ft. wide, and each has an active hearth area of 1,495 sq.ft. A cooling hearth adjoins each roaster at the discharge end, which is 44 ft. long by 13 ft. wide. Roaster hearths have a slope of 1 in. per foot.

Each roaster is equipped with 74 revolving rabbles, 54 being in the roaster proper and 20 on the cooling hearth, which move the ore from feed end to discharge end of the furnace. The rabble arms of the roasting hearth revolve at a speed of 3 r.p.m. and those of the cooling hearth at 6 r.p.m. Each roaster requires 16 hp. for operation. Ore passes through the roaster in average time of 5 to 6 hours.

Coal (Colorado Springs lignite) consumption ranges from 170 to 180 lb. per ton of ore roasted, and an additional 8 per cent is required to generate the steam for the producer. The gradual increase in the amount of concentrates going to the roaster has helped to lower the coal consumption.

The calcines are cooled to 85 deg. C. and delivered at 2.5 per cent moisture to the Chilean mills (six instead of five) for grinding, as described in Information Circular 6739.

The pulp from the Chilean mills is fed onto 6x12-ft. blanket tables, where the so-called coarse gold is recovered. The blankets are light-weight canton flannel and are changed every 12 hours. They are washed by sprays and also in a barrel washing machine, thereby recovering the concentrates; the latter account for from 22 to 40 per cent of the total gold recovered. This gold is recovered from concentrates by amalgamation in grinding pans, mercury being added to the pulp in the pans; amalgamation of the concentrates is done in regular mill cyanide solution. Overflow from the grinding pans passes over blankets and then into the general mill circuit. The amalgam obtained is retorted and the gold bullion of 920 to 940 fineness in gold and 45 to 55 fineness in silver is shipped to the Mint at Denver.

Sands are leached as described in the Information Circular, save that the classifiers have 15-ft. bowls (instead of 12-ft.) and that there are ten vats instead of eleven, each of 10 ft. 9 in. depth instead of 7 ft. and with a capacity of 900 tons of dry sand instead of 600. Water at 120-lb. pressure instead of 200-lb. is used to discharge the vats.

Slime treatment is somewhat different from that described in the Information Circular, as follows: The overflow pulp of the Dorr bowl classifier, containing about 7 per cent of solids, is thickened to 43 per cent solids in a 50-ft. Dorr tray thickener, the overflow solution being returned to the Chilean

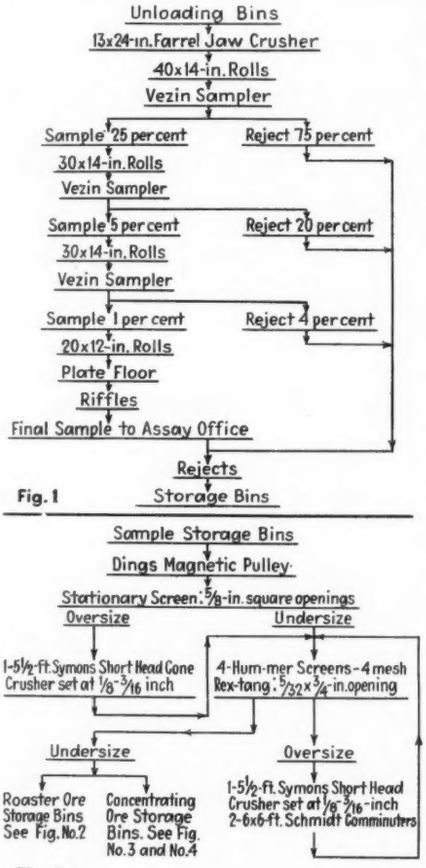


FIG. 1—THE SAMPLER of the Golden Cycle plant consists of two duplicate units, each having this flowsheet. Fig. 1-A — The flowsheet of the secondary crushing plant

mills. This solution in ordinary plant practice would go direct to precipitation after clarification, since it is the richest in gold values; however, in this plant, on account of its carrying considerable sulphate in solution, having been warmed during the grinding of hot calcines, it must be circulated around the plant until it cools down and drops its load of soluble salts; otherwise, these salts will crystallize out in the precipitation presses so rapidly as to raise the pressure to a dangerous point in a short time, thereby cutting the capacity of presses to very low tonnage.

The thickened pulp is discharged and pumped to a 41x26-ft. Dorr agitator. The thickened tailings—coarse sand having been removed previously—from the concentration plant join the roasted slime at this point, being pumped to the agitator above with the 50-ft. tray thickener slimes. The overflow from this agitator passes to two Dorr agitators, and from these it passes to a mechanical agitator. From the latter the pulp passes to another Dorr agitator and then to three Dorr tray thickeners and one Hardinge Superthickener. The solids from these thickeners are pumped to another Dorr agitator, and from there flow to two mechanical surge tanks, which are filled alternately, these tanks feeding the Butters filters. The solution from the three Dorr thickeners and one Hardinge secondary thickener passes to gold storage tanks.

Total time of agitation amounts to approximately 65 to 75 hours. The solids handled contain 4 to 5 per cent plus 100 mesh and approximately 84 per cent minus 200 mesh.

Filtering is as described previously, save that there are 121 6½x9½-ft. canvas-covered frames. Tailings contain 0.02 oz. of gold per ton, of which $0.0245 is soluble.

Solution clarification at this plant is best effected by sand vats—that is, by passing the unclarified solution through a regular charge of sands in leaching vats during the leaching cycle. An ordinary leaf-type clarifier, rarely used, is also installed. The Hardinge thickener is sometimes used as a clarifier.

Precipitation by zinc dust and Merrill presses is accomplished as previously recounted, and the use of lead acetate is continued. Smelting of the precipitate, dried and fluxed, to bullion is done as before, with the addition of a further refining in a graphite crucible furnace. Slag from this work is crushed and amalgamated.

Recovery at this plant is approximately 95 per cent, which includes values shipped to the smelter as well as those shipped as bullion to the Mint at Denver.

Solutions vary widely in their cyanide and lime content, titration showing from 0.7 lb. NaCN per ton of solution to 1.25 lb. NaCN per ton of solution and in lime from 0.1 lb. CaO to 1 lb. CaO per ton of solution. Black cyanide only is used in this plant. Both hydrated and burned lime are used. The latter is slaked before mixing with the ore. A close check is maintained at all times on strength of solutions, as the various classes of ores and varying amount of concentrates being treated make this imperative.

The general mill heads vary from 0.30 to 0.37 oz. gold per ton. Recovery is approximately 95 per cent of gold values, as mentioned in the foregoing.

The cost of actual operation and repairs at this plant, exclusive of taxes, amortization of plant, and incidental expense, is $1.50 per ton of ore treated. This covers the combined costs of various departments of both the cyanide

and concentration plants. The sampling cost accounts for a considerable part of the total on account of this plant's being a custom mill.

As for the function of the concentrator, which is not described in the Information Circular previously referred to, the concentration process is used on some ores to beneficiate them, and on others to remove cyanicides or other deleterious substances prior to the cyanidation of the remaining material. As a means of beneficiation, it is best illustrated in the treatment of the low-grade Cripple Creek gold ores. These are too low in grade at times to roast profitably, so they are concentrated and only the concentrates are roasted before cyanidation, the latter amounting to 3 to 5 per cent of the original ore. The concentration tailings are then cyanided, and a very low tailing is obtained. In complex ores, a concentrate containing lead and copper or the latter alone is removed, which is shipped to the smelter, and then an iron concentrate is made, which must be roasted before cyanidation. Likewise, in ores from the Alma district (the London mine) a carbonaceous shale is present, which would cause premature precipitation of the gold if left in the product going to the cyanidation plant. This is removed either in the lead-copper froth or in the iron froth, most of it going with the former, as it floats readily, although consuming excessive amounts of oil. The iron concentrate, after roasting with the regular "roaster" ore, passes over blankets to remove the free gold.

Thus, concentration, as employed at the Golden Cycle mill, is a preparatory, not a finishing, process. It leaves to the cyanide plant the work of recovering most of the recoverable gold, either from the flotation tailings or the roasted iron concentrates. Inasmuch as we do not depend upon the concentrator to make a final tailing, we can carry a much higher tonnage at a considerably coarser grind than could be done otherwise, and the over-all recovery is just as high as though the concentration made a much lower tailing. The cost of treating the flotation tailings by the cyanidation process is a small additional amount, which is assumed to be approximately 15 to 20c. more than it would cost to discharge them to waste. One will see therefore that to justify sending these tailings to waste, instead of cyaniding them, their gold content must never exceed 0.02 oz. gold per ton. This result, however, is almost impossible of attainment, because a great variety of ores, some very complex and refractory, are treated in the plant. On some ores, indeed, a tailing of 0.02 oz. gold, and even less occasionally, could be obtained, but it would be impracticable to try to segregate and treat them by concentration only.

In addition to removing undesirable constituents from the ores, the concentration process also eliminates the detrimental effects of soluble salts that occur in the original ores, by aëration and washing and later precipitating them when lime is added to settle the pulp. It also oxidizes any reducing salts that may have been present originally.

Standard practice is used throughout the concentrator. However, on account of the wide variety of ores, a flexible arrangement of equipment must be maintained to provide the best flowsheet for the particular ore being treated at the time. To this end, launders, pumps, elevators, and the like are so arranged that the pulp can be directed to almost any machine in any sequence in relation to the other machines.

The ores treated are divided into three classes and are bedded accordingly. These are as follows:

1. Straight gold ores carrying little or no silver. Cripple Creek ores of lower grade are included in this class, together with gold ores from other districts which carry below 5 oz. in silver. Bulk concentration is practiced on these.

2. Gold-silver ores, including all ores carrying over 5 oz. silver per ton and with little or no lead and copper or copper alone. Selective flotation is practiced on this class.

3. Ores carrying appreciable amounts of lead and copper, with or without gold and silver or silver alone. Seldom are ores which do not carry gold and silver or silver alone shipped to the plant. Selective flotation is practiced on this class also.

To clarify the flowsheets in Figs. 3 and 4, a brief description is given of the general treatment under each. Inasmuch as the straight gold ores contribute the largest part of the tonnage treated, their treatment will herein be discussed first.

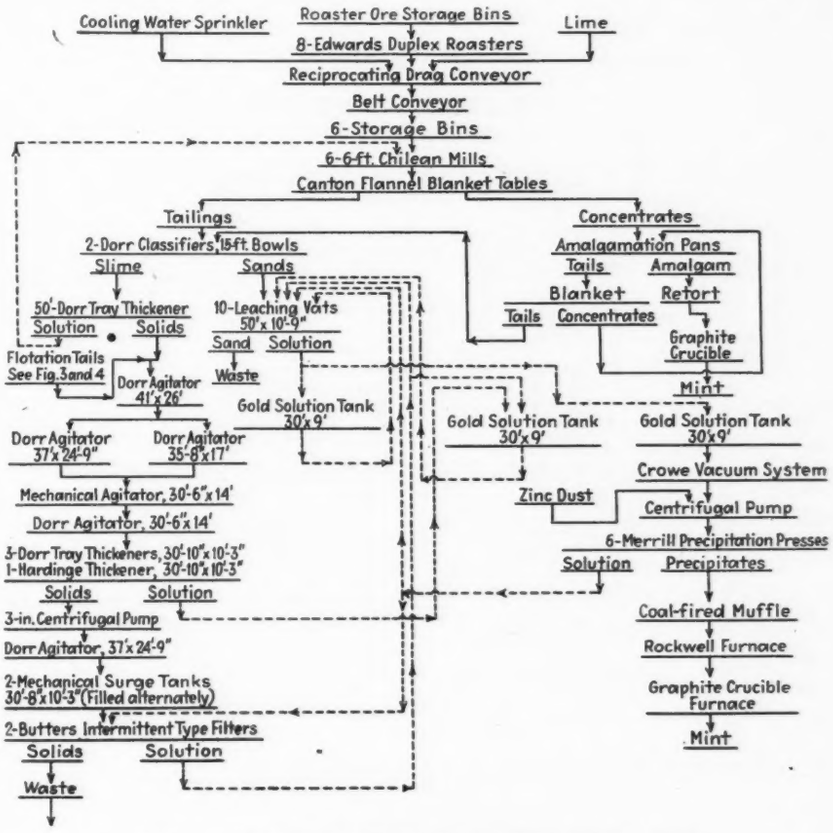


FIG. 2 — AVERAGE-GRADE ORES from Cripple Creek, when treated in the roasting and cyanide plant, are handled according to this flowsheet

In grinding the straight gold ores (Fig. 3), the ball mills used are of the grate-discharge type, have scoop feeders, and revolve at 23 to 24 r.p.m. Feed is minus 4 mesh. The ball load is kept 6 to 12 in. below the trunion intake liner. The discharge is approximately 72 to 78 per cent solids and at times may get as high as 80 to 81 per cent. Balls are added at regular intervals, once in 24 hours, and are cast 2½ and 3 in. in diameter. Ball consumption amounts to 1.7 lb. per ton of ore ground and liner consumption 0.2 lb. per ton of ore ground.

Screens used are of the ordinary trommel type 4 ft. in diameter and 4

ft. long, equipped with 6-mesh screen having approximately 0.10-in. square opening.

A typical grind on this class of ore is given in Table I. The specific gravity of the dry ore is 2.6 to 2.7; the number of mills is three; tonnage is 444; run, 24 hours; specific gravity of classifier overflow 1.250; speed, 22 strokes per minute; slope, 2½ in. per foot.

The ore pulp is elevated from the ball mills to a screen, the oversize re-

Table I—A Typical Grind on Straight Gold Ores

Mesh		Individual %	Cumulative %
Plus	35	1.2	...
	48	4.5	5.7
	65	11.8	17.5
	100	16.6	34.1
	150	12.0	46.1
	200	10.3	56.4
Minus	200	43.6	....

sprays using cyanide solution that carries sufficient lime and cyanide to effect a partial dissolution of the gold and

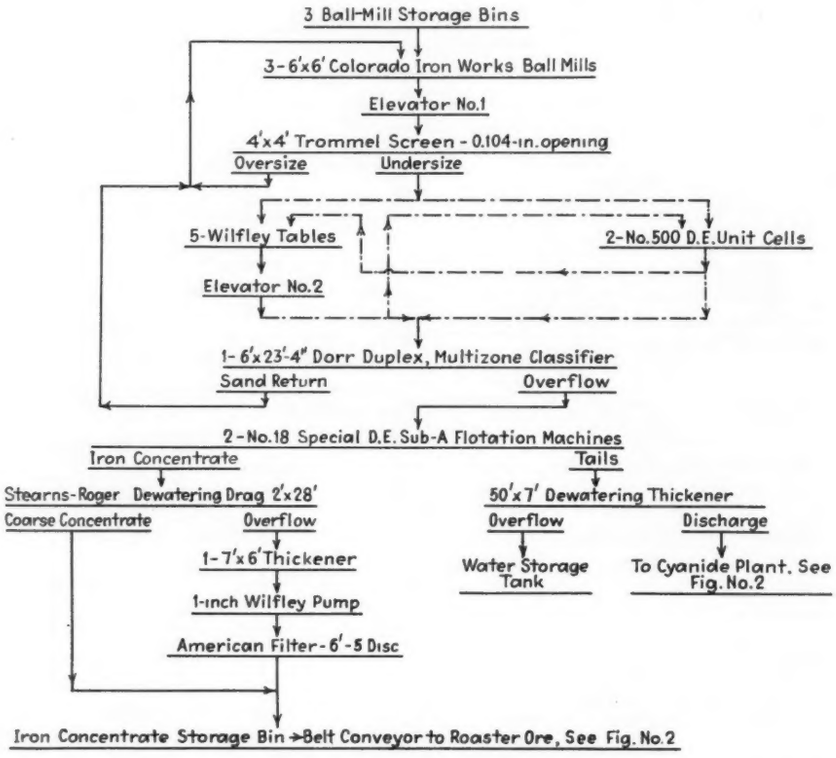


FIG. 3—LOW-GRADE ORES from Cripple Creek and gold ores from other districts are treated according to this flowsheet in the concentrator

turning and the undersize passing to Unit Sub-A flotation cells and then to tables, or to the tables first, then to the Unit cells, and back to the classifier. Classifier overflow passes to Nos. 1 and 2 flotation units, which run in parallel. The tailings from these two pass to No. 3 unit, a bulk concentrate being taken from each and combined with the table and flotation cell concentrates in a pump which delivers to a Stearns-Roger drag dewaterer. The overflow from the latter may or may not go to an agitator before being thickened and filtered. Dewatered coarse concentrates drop into concentrate storage bins together with the filtered fine concentrates and pass to the secondary crusher plant along with the "roaster" ore. All finished concentrates are washed down the launders with silver values as it passes along the circuit.

Concentration tailings pass to a dewatering thickener and from there to the cyanide plant.

In treating gold-silver ores (Fig. 4), the grind is slightly finer than on the straight gold ores. Table II gives a typical grind. The specific gravity of the dry ore is 2.6 to 3.2; the number of mills is three; tonnage, 400 per 24

Table II—A Typical Grind on Gold-Silver Ores

Mesh		Individual %	Cumulative %
Plus	35	...	...
	48	...	...
	65	1.9	...
	100	7.8	9.7
	150	12.5	22.2
	200	14.3	36.5
Minus	200	63.5	....

hours; specific gravity of the classifier overflow, 1.150; speed, 17 strokes per minute; slope, 2½ in. per foot.

The ore pulp discharged from the ball mills passes to the elevator and then directly to the classifier, bypassing the screen. From the classifier, the overflow passes to Nos. 1 and 2 flotation units, operated in parallel, where a gold-silver-lead-copper concentrate is taken off, the zinc and iron sulphides having been depressed, just a sufficient amount of concentrates being pulled to obtain all of the lead and copper minerals and as much of the silver values as possible without making an excessive amount of concentrates. This concentrate is thickened (cyanide solution having been used in sprays on finished concentrate), filtered, and dried in storage bins having steam coils in the bottom. It is then shipped to Leadville. Tailings from Nos. 1 and 2 units pass to No. 3 unit, where an iron-zinc concentrate is removed, which is mixed with the table concentrate, the combined concentrate going to the dewatering drag, from which point on it is given the same treatment as the bulk concentrate made on straight gold ores. The tailings from the No. 3 flotation unit then pass to the tables, where a rough concentrate and a middling streak are cut and handled as previously told. The table tailings are given the same treatment as those from straight gold ores.

Under present operating conditions in the cyanide plant, which with the roasters is treating an excess tonnage, it is not desirable to have much silver in the material going through, for two reasons: (1) the silver is as a rule slower in extracting, and (2), due to the formation of soluble alkaline sulphides periodically in the roasting on account of excessive amounts of concentrates being roasted, a precipitation of the silver occurs prematurely, which of course is undesirable. Another reason for attempting to ship all silver possible to the smelter is that it has been found desirable to roast all iron concentrates, which of course carry considerable silver at times. Upon roasting them, the silver is locked up in such a manner as to make it hard to recover it in subsequent cyanidation treatment.

In treating the complex gold-silver-lead-copper-zinc ores (Fig. 4), there is little difference from the foregoing save that the screens and unit flotation cells are used. The ore, after being ground, goes to the elevator, which delivers it to screen, the oversize passing to ball mills and the undersize to the Unit flotation cells, where as much of the free gold is removed in both the froth and the cone discharge as possible. This is passed through a Wheeler pan for amalgamation, the overflow returning in the circuit to the ball mills. Thus the gold content of the lead-copper concentrate going to the smelter is much reduced, the gold recovered by this

amalgamation being shipped to the Mint rather than to the smelter. Tailings from the Unit cells pass to the classifier, the overflow of which is same as for the gold-silver ores.

The classifier overflow passes to Nos. 1 and 2 flotation units, where a lead-copper or, in some cases, a straight copper concentrate is removed and given the same treatment as in the case of gold-silver ores. The tailings from these two units pass to No. 3 flotation unit and to tables, where iron concentrate is removed as previously described, the concentration tailings going to a dewatering thickener and the cyanide plant.

Reagents used here are standard, such as used in most mills: soda ash, xanthate (Z-4 and Z-5), pine oil, coal-tar creosote, cresylic acid, cyanide and zinc sulphate, and copper sulphate. Conditioning reagents are fed to the ball-mill circuit or to conditioners, as are likewise iron and zinc inhibitors.

In selective flotation, when cyanide is used as an iron depressant or a combination of cyanide and zinc-sulphate for depressing iron and zinc or zinc alone, we have found that the concentration tailings will contain soluble gold, even when as little as 0.05 lb. NaCN per ton of ore is used in a pulp of 5 to 1 dilution, there being insufficient cyanide in the water to be able to detect it even when titrating as much as 500 cc. by ordinary methods. The solution from these tailings at times will assay $0.20 to $0.40 per ton of solution, when treating high-grade free gold ores. Various depressants have been tried, but none have been found as efficient as cyanide. Consequently, the overflow water from the dewatering thickener must be returned to the flotation plant for re-use and kept in closed circuit for so long a time as cyanide is being used in flotation. Usually, two or three days after stopping the use of cyanide in flotation, the soluble gold in the solution is sufficiently low (only a trace) to be run to water storage tanks instead of re-using in flotation plant. By following this method, the soluble gold gradually works its way into the cyanide plant with the thickened pulp, so that it is not lost.

Inasmuch as lime is used for settling the pulp in the dewatering thickener, this introduces trouble in the flotation, when using this return water. To reduce this to the least possible, the lime is kept at the absolute minimum in this thickener that will give a clear overflow. Flotation men check this every hour by titrating with a dilute standard acid, maintaining the CaO content at a trace to 0.05 if possible. At times, to settle the ore, one must carry a higher lime content so as not to throw too much water into the cyanide plant with the concentration tailings. The ill effect of this lime content in the return water is sometimes counteracted by the use of soda ash in the grinding circuit. Again, if an excess of soda ash is used in the flotation circuit on an ore that is already settling poorly, a greater excess of lime must be used to obtain a clear overflow in the thickener. It is apparent that unless extreme care is exercised, an endless circle of excessive amount of lime in settling, followed by an excessive amount of soda ash in flotation, is formed, which is very undesirable. As a rule just sufficient soda ash is used to maintain a pH value of 7.2 to 7.6 in the lead-copper circuit, or slightly above the neutral point. If too high a pH is carried with soda ash, the condition mentioned would obtain, whereby excess lime would have to be added to flocculate the pulp after it had been deflocculated by the soda ash.

Inasmuch as the water is returned from the dewatering thickener, some reagents are left from the iron flotation, and rarely is it necessary to add any frother or collector in the lead-copper circuit. In fact, the oils and xanthate used in flotation of iron mineral are kept as high as possible, to obtain as much mineral as possible in the iron float and yet not cause trouble in the flotation of lead-copper minerals. Copper sulphate is used to activate the iron mineral in the No. 3 flotation unit, and cyanide and zinc sulphate are used, as previously mentioned, to depress the iron. Of course, the lime in the return water acts as a good depressant for iron, and consequently not much cyanide is required—merely enough, in conjunction with zinc sulphate, to depress the zinc. The amounts of reagents used vary so widely, due to the great variety of ores treated, that the reagent consumption cannot be stated except in a general way.

Recoveries of the various metals vary widely. As a rule the lead and copper in the tailings from Nos. 1 and 2 flotation units are very low, the lead being below 0.5 per cent and the copper below 0.1 per cent. Because the tailings are cyanided, we desire to keep the copper content as low as possible, even though in so doing the grade of the concentrate going to smelter is made low. Frequently the copper in tailings is as low as 0.05 per cent to a trace. A general rule as regards the recovery of metals may be stated as follows: Keep as much gold in the plant as possible to ship to the Mint, and ship as much lead, copper, and silver as possible to the smelter, for the reasons already discussed in the foregoing.

In preparing this paper, I am greatly indebted to the management of the Golden Cycle Corporation and to various members of the mill staff, particularly to L. S. Harner, general manager of the mill, and to M. F. Dycus, superintendent of the cyanide plant.

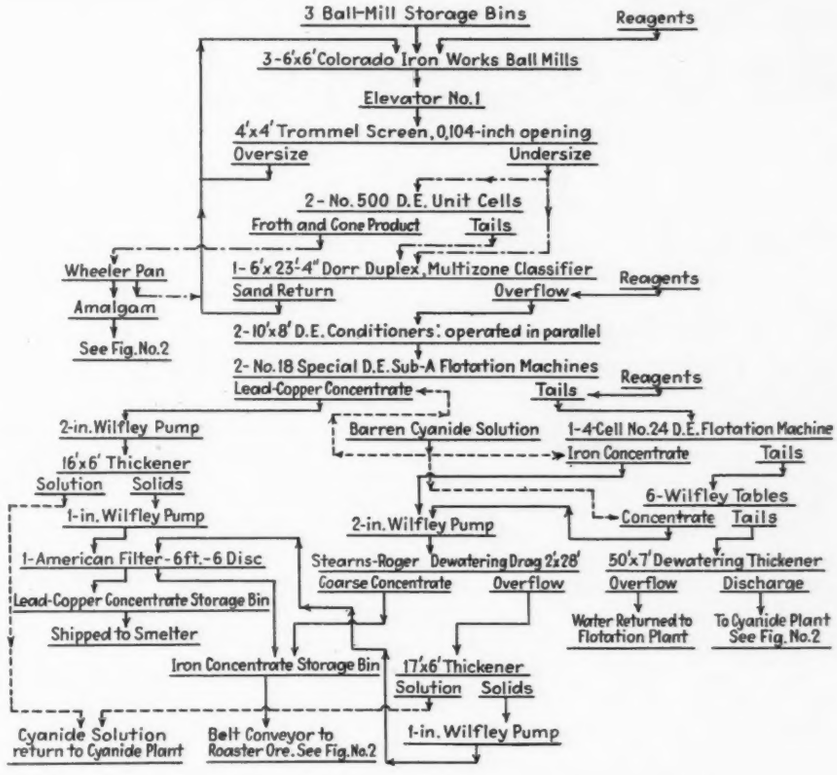


FIG. 4 — COMPLEX ORES, containing gold, silver, lead, copper, zinc, are handled in the Golden Cycle concentrator as shown in this flowsheet, as explained in the text

CAMPS OF THE

Operations Promising at Ouray,

Geologic Guides Are Sought For Ore Development

Principal area still productive—Completion of map of Silverton unit will permit systematic exploration

W. S. Burbank
Geologist in Charge
U. S. Geological Survey
Golden, Colo.

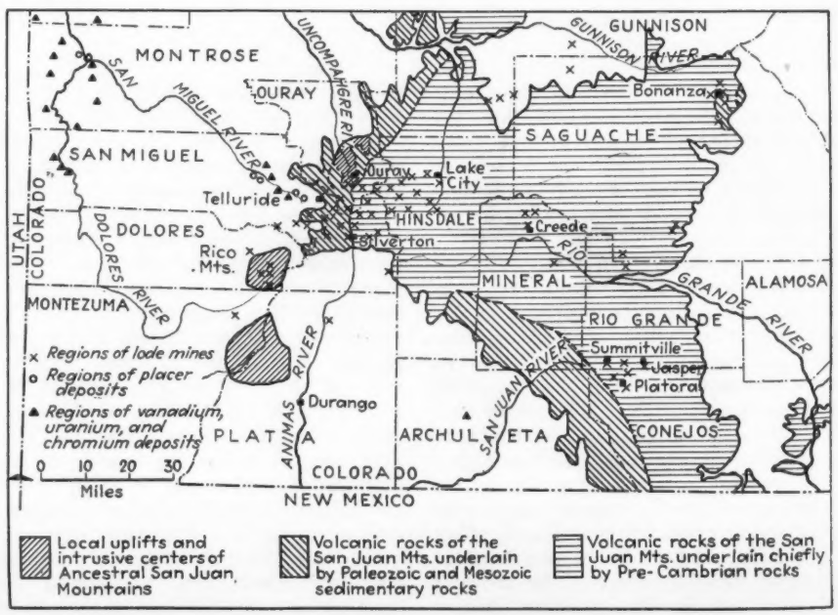
THE San Juan region of southwestern Colorado is generally regarded as a high Tertiary volcanic plateau, out of which the present mountains have been carved by erosion; but this picture represents only the later stages of geologic history, whereas a complete picture must represent also the older, ancestral mountain groups that make up part of the western San Juan and have an important bearing on our knowledge of the ore deposits of the region. In this review the ore deposits are recognized as belonging to three geologic and metalliferous provinces: (1) The early Tertiary Ancestral San Juan Mountains; (2) the late Tertiary San Juan Mountains; (3) outlying districts mineralized in Pre-Cambrian and Tertiary time.

In the younger San Juan Mountains, especially their eastern part, most of the outcropping formations belong to the late Tertiary volcanic group of breccias, bedded tuffs, lava flows, and sedimentary beds, which are at present nearly horizontal or only moderately tilted from their original position. This group is more than a mile thick in places, even though erosion has stripped the younger deposits from the crest of the mountains. West of the continental divide the deeper canyons have cut through these later Tertiary rocks, which have been locally uplifted and tilted eastward, and have exposed the underlying older mountains whose formations range in age from Pre-Cambrian to late Cretaceous or earliest Tertiary, and include Paleozoic and Mesozoic sedimentary formations. These formations attain a total thickness of 10,000 ft. or more in the southwestern San Juan, but at present, because of the early Tertiary uplift of the San Juan dome and the subsequent beveling of the sedimentary rocks by peneplanation, the remnant of sedimentary blanket decreases gradually or abruptly in thickness toward the ancestral mountains. The core of this ancestral range now lies mostly concealed beneath late Tertiary lavas in the central western part of the later San Juan uplift.

Since both the early Tertiary doming of the ancestral mountains and the late Tertiary volcanic eruptions were accompanied by intrusions of igneous bodies with their associated metalliferous emanations, ore deposits were formed under a great range of environmental conditions. These are summarized briefly in the accompanying table (p. 389). For completeness, Pre-Cambrian deposits and periods of placer concentration are included, though some of these have not yet proved of great economic importance.

Most of the metal production has come from veins of Epoch V in western areas that constitute 10 per cent or less of the San Juan Mountains (Fig. 1.) The Creede district, only major producer of the eastern central San Juan, has accounted for about $43,200,000 of the total under V-A of the table. Furthermore, most of the output of the western districts grouped under V-A and V-B has come from volcanic and not sedimentary rocks. It is realized that mining has never been deep enough to test the sedimentary rocks beneath the lavas thoroughly, and in recent years, because of the continued depletion of ore reserves in volcanic rocks, engi-

FIG. 1—SAN JUAN MOUNTAINS in Southwestern Colorado, showing distribution of volcanic formations and the underlying sedimentary rocks and principal areas of mineralization



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SAN JUAN

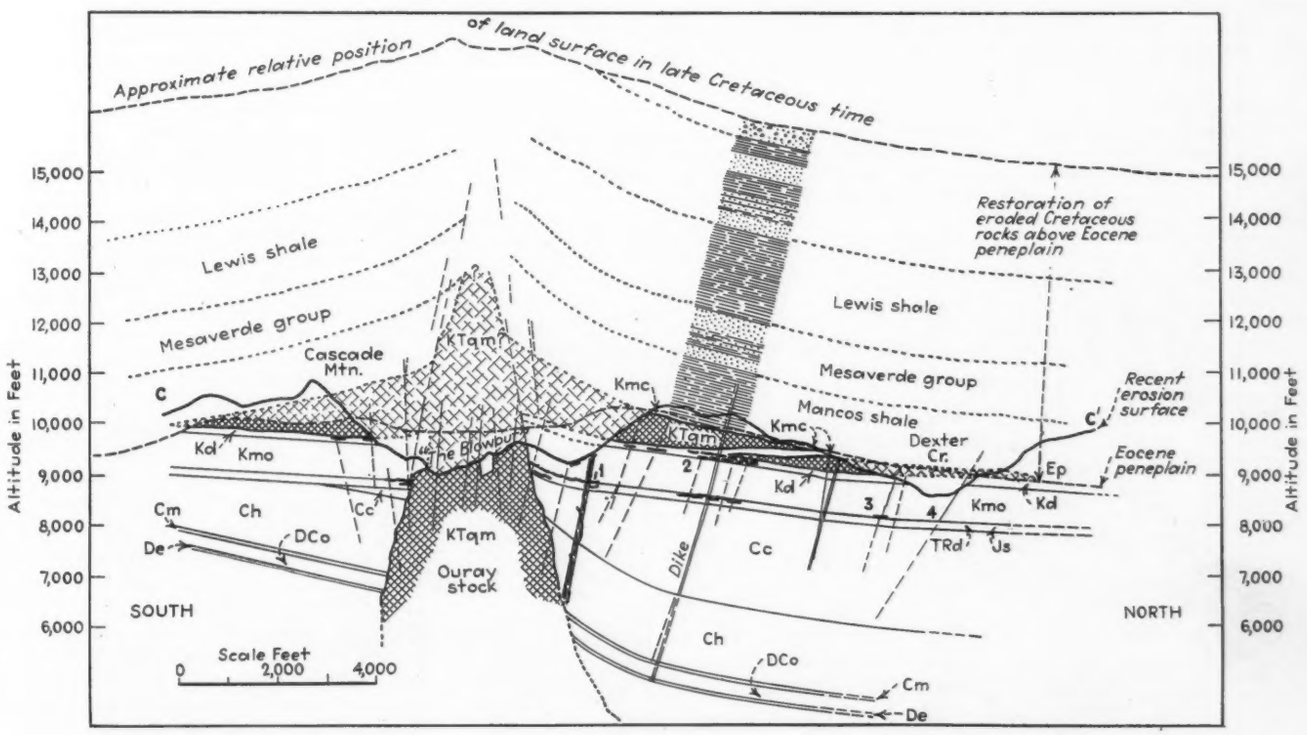
Rico, Silverton, and Telluride

neers have given more thought to the question of deep ore reserves in the concealed limestones of Devonian, Mississippian, and Pennsylvanian age. Purington[1] raised this question in 1899, and it is invariably asked of geologists who work in the region.

At the time of Purington's report the existence of two epochs of ore deposition, III and V, was not recognized, and all deposits of the western San Juan were attributed to Epoch V; but it has recently been shown that the ores in the sedimentary beds in the Uncompahgre district near Ouray belong to Epoch III[2]. By comparison of intrusive rocks and ores, and especially the existing physiographic and structural conditions, we may conclude that ores of the Rico and La Plata Mountains likewise belong to this older epoch, though it must be emphasized that a definite proof of the age of the Rico and La Plata deposits remains to be established[3]. At the time of Epoch III a great thickness of sedimentary rocks overlay the Pre-Cambrian basement of the present site of the western San Juans. The upper parts of this section contained deposits of marine shales belonging to the Mancos and Lewis shales of the southwestern Colorado area, besides many interbedded shales and sandstone of marine and freshwater origin. In the Ouray district open mineralized fissures of Epoch III passing from the underlying more massive Dakota and Jurassic sandstones and paleozoic rocks, into the overlying mancos shale can actually be seen to end entirely in a roll of contorted shale or pass into tight and narrow weakly fissured zones in the shale. See Fig. 2.)

Contrast these conditions with those that existed during the mineralization of Epoch V. (See Figs. 3 and 4). As shown in the table, practically all of the upper Cretaceous shales had been removed by erosion in the intervening time, and in addition the underlying Paleozoic formations were also partly removed from large parts of the mineralized districts. The increased metamorphism and fracturing of the Paleozoic rocks effected in Epoch V had perhaps also rendered them somewhat more favorable to the retention of open fissures. Strong fissures originating deep

FIG. 2—GEOLOGIC ENVIRONMENT, historically restored, of the Ouray stock in late Upper Cretaceous or early Eocene time. The positions of both veins and flat-lying replacement and disseminated deposits are indicated by broken and solid lines and by markings parallel to the bedding of the sedimentary rocks. The larger mines along the line of the section are shown by numerals. (1) Wanakah and Bright Diamond mines. (2) American Nettie mine. (3) Bachelor mine. (4) Calliope mine. Blank spaces above the Eocene peneplain surface and below the line of the Recent Erosion Surface are now occupied by Tertiary volcanic accumulations



LEGEND

Ep, surface of Eocene peneplain
De, Elbert formation (Devonian)
DCo, Ouray and Leadville limestones (Devonian and Mississippian)
Cm, Molas formation (Pennsylvanian)
Ch, Hermosa formation (Pennsylvanian)
Cc, Cutler formation (Permian chiefly)
TRd, Dolores formation (Triassic)
Js, Entrada sandstone (Jurassic)
Kmo, Morrison formation (Jurassic)
Kd, Dakota sandstone (Upper Cretaceous)
Kmc, Mancos shale (Upper Cretaceous)
KTqm, Early Eocene intrusions of porphyritic igneous rocks, chiefly diorites, quartz monzonite, and related materials

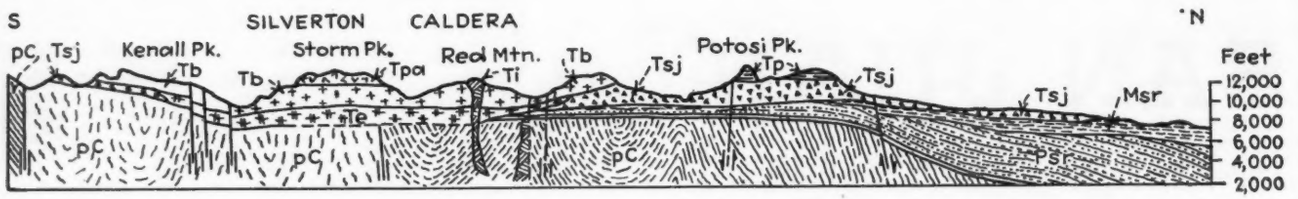


FIG. 3—THE UPLIFT of the ancestral mountains and erosion of the sedimentary formations beneath the Tertiary volcanic rocks, and the structure of the Silverton caldera, illustrated in geologic section about N. 20 W. across the western San Juan Mountains. Geologic legend as follows: Pc, Pre-Cambrian formations; Psr, Paleozoic sedimentary formations; Msr, Mesozoic sedimentary rocks; Tsj, San Juan tuff; Te, Eureka rhyolite; Tb, Burns latite; Tpa, pyroxene andesite; Tp, Potosi rhyolite; Ti, Tertiary intrusions

in the earth's crust thus passed directly through the comparatively thin remaining shell of the sedimentary blanket, and through the massive volcanic rocks to the surface.

Contrast the great length, and depth, of the Smuggler Union productive oreshoots to any known open fissures in Rico, Leadville, or the Uncompahgre district. Solutions depositing ores in these fissures took the easiest and most direct path to the surface. The proportion of forced lateral migration in porous sedimentary rocks was therefore greatly reduced. Some small lateral replacement deposits along fissures of Epoch V are known to exist in limestones and breccia beds, but their dimensions are measurable in feet rather than tens or hundreds of feet.

Thus it appears that throughout most of the areas of mineralized volcanic rock of the western San Juan large tabular replacement bodies in the underlying sedimentary beds are not likely to be found along the veins of Epoch V. The simple veins themselves may contain sufficient ore to warrant stoping within sedimentary rocks, but deep development should not rely solely upon replacement orebodies to defray the increased cost of mining. Under the conditions represented by V-C, where increased thicknesses of the sedimentary blanket remain uneroded, more lateral replacement may have taken place, but in the province indicated in V-C, which is perhaps best represented by the late Tertiary intrusive centers of the Mount Wilson group, the depths to the most favorable sedimentary horizons are greatly increased.

The known ore-producing regions of the ancestral San Juan Mountains are chiefly concentrated in outlying domes along the western edge of the ancestral uplift. Three principal areas account for the bulk of the output from this geologic division—namely, the Uncompahgre district at Ouray, the Rico Mountains, and the La Plata Mountains. All three of these centers are characterized by intrusive stocks, laccoliths, sheets, and dikes of porphyritic igneous rocks, and by local doming of the Paleozoic and Mesozoic formations above the intrusive centers. In the Rico and La Plata Mountains the domal structures are well exposed.

For descriptions of the structure, sedimentary and igneous rocks, and ore deposits of these districts reference should be made to other publications.[4]

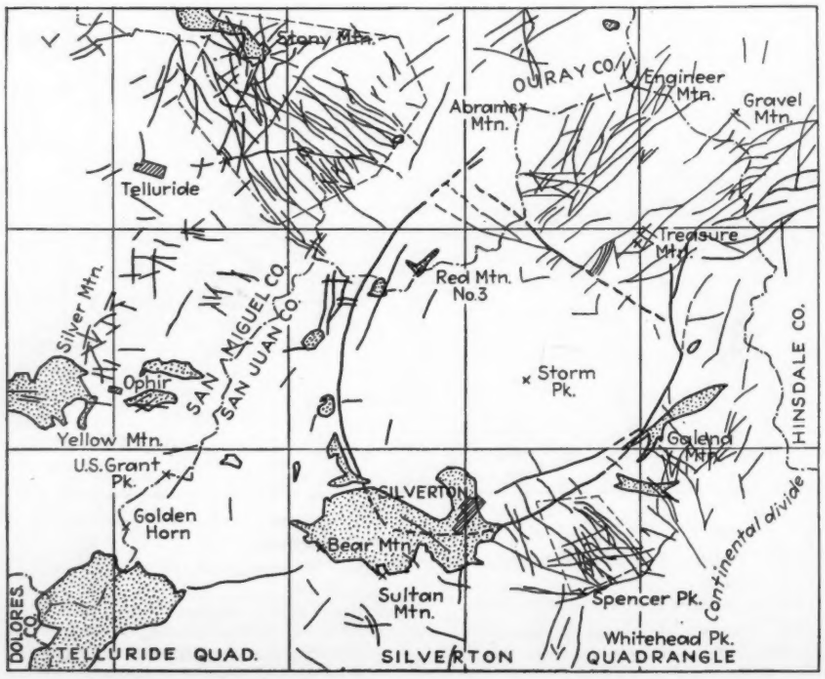
The application of geologic principles in the development of these ore deposits is much like that already applied for many years in the development of the mesothermal ore deposits of Leadville, Aspen, and other mining districts of central Colorado, which are approximately the same epoch of mineralization. As a whole, however, the deposits of the ancestral San Juans indicate formation at lower temperature, and overlap the epithermal zone of Lindgren.[5] This difference is to be expected, since only the shallower portions of the domes are exposed by erosion, the related intrusive igneous centers are more localized and somewhat smaller, and fracturing and faulting are less extensive.

The Devonian and Mississippian limestones are only exposed a little south and off-center of the Ouray dome. They are largely concealed except possibly in small blocks in the very center of the Rico dome, and are still rather deeply buried in the La Plata dome. After the more superficial deposits of these centers have been thoroughly developed, the obvious future development would be in these deeper limestone horizons.

Comparison of zoning and mineralogy shows some differences between the San Juan and Leadville regions,[6] so that direct comparison of the districts is likely to be misleading.

A problem of practical importance in the ancestral San Juan domes is that related to the occurrence of thermal springs, entrapped gases, and rocks heated above the normal thermal gradient. These features do not necessarily represent manifestations of the latest igneous phenomena of the San Juan region, but result because heat is slowly dissipated through the finely laminated and slightly fractured sedimentary blanket, and also because the relatively impervious shales have assisted in retaining gases and solutions which are still reacting with the organic matter

FIG. 4—FRACTURE SYSTEMS in pattern and principal crosscutting intrusive bodies in the Silverton quadrangle and eastern part of the Telluride quadrangle. Two areas which have been mapped on a scale of 1 in. equals 1,000 ft. are outlined by light dashed lines



Tabular Summary of Mineral Deposits of the San Juan Region

Metallogenetic Epoch	Environmental Conditions and Processes of Concentration	Form of Deposits and Metal Concentration	Production[1]
I. Pre-Cambrian	Deep erosion exposing schists and gneisses invaded by batholithic granite and diorite.	Chiefly veins containing gold or copper ores	
II. Jurassic	A. Continental sedimentation on the peneplained borders of Paleozoic and Pre-Cambrian ranges. Sandstone deposits, resting on Pre-Cambrian.	A. Minor placer concentration of gold, probably from the Pre-Cambrian veins.	None
	B. Continental sedimentation and groundwater movements around borders of Paleozoic and Pre-Cambrian uplifts. Sandstone deposits of Triassic and Jurassic age, resting upon Mesozoic or Paleozoic sedimentary rocks.	B. Chiefly concentrations of vanadium, chromium, and uranium. Replacement deposits in sandstones. Minor veins in sandstone.	3,054,374 lb. vanadium 1909–1923[2]
III. Eocene or late Cretaceous	Development of Ancestral San Juan Mountains Stock-like and laccolithic intrusions of diorite, granodiorite, granite, and related rocks, generally porphyritic. 5,000 to 10,000 ft. of sedimentary cover; chiefly Cretaceous marine shales in upper part.	Veins, tubular or tabular replacement bodies, and transitional forms. Lead, zinc, silver, and gold ores.	$35,500,000 (approximate only to 1933). Au:Ag::1:50
IV. Late Eocene or Oligocene	Continental sedimentation on peneplained surface of Ancestral San Juan Mountains. Conglomerate, sandstone, shale.	Minor placer concentration of gold. Probably derived from gold deposits of III.	None
V. Middle to late Tertiary	Development of younger San Juan Mountains A. Several hundred to 5,000 ft. of volcanic rocks, resting chiefly on Pre-Cambrian rocks. Cut near local volcanic centers by igneous stocks and large fault zones.	A. Chiefly vein deposits in the Tertiary volcanic rocks. Minor veins in underlying Pre-Cambrian rocks. Local stockworks or pipes. Silver, gold, and base-metal ores.	$165,000,000 (approximate to 1929). Au:Ag::1:57
	B. (Chiefly in western marginal part of San Juan uplift). Blanket of sedimentary rocks up to 4,000 ft. in thickness, from which Cretaceous shales have been largely removed, covered by several thousand feet of volcanic rock. Sedimentary and volcanic rocks cut by igneous stocks.	B. Chiefly veins in Tertiary volcanic rocks. Smaller veins in underlying sedimentary rocks. Minor small lateral replacement bodies in sedimentary rocks near veins. Silver, gold, and base-metal ores.	$180,000,000 (approximate to 1929. Probably less than $5,000,000 from sedimentary rocks). Au:Ag::1:18
	C. (Western marginal part and outlying stocks and sheets in sedimentary rocks.) 4,000 to 8,000 ft. of sedimentary cover, including Cretaceous shales, in part overlaid by volcanic accumulations up to a few thousand feet in thickness.	C. Veins in both volcanic and sedimentary rocks. Disseminated ore in the sedimentary beds. Chiefly silver and gold ores.	Production not definitely known, but probably less than $10,000,000.
VI. Quaternary to Recent	A. River valleys, flood plains, terraces. Canyon cycle of erosion. Gravels and sands.	A. Placer concentrations of gold.	$250,000

[1]Production based upon preliminary classification of deposits, and records in Prof. Paper 138, "Mining in Colorado," by C. W. Henderson (1926) and later records of the U. S. Bureau of Mines.

[2]Including deposits of the San Miguel Valley near the San Juan Mountains, only: Hess, F. L.: Uranium, Vanadium, Radium, Gold, Silver, and Molybdenum Sedimentary Deposits. "Ore Deposits of the Western States." Lindgren Volume (A. I. M. E.), p. 461, 1933.

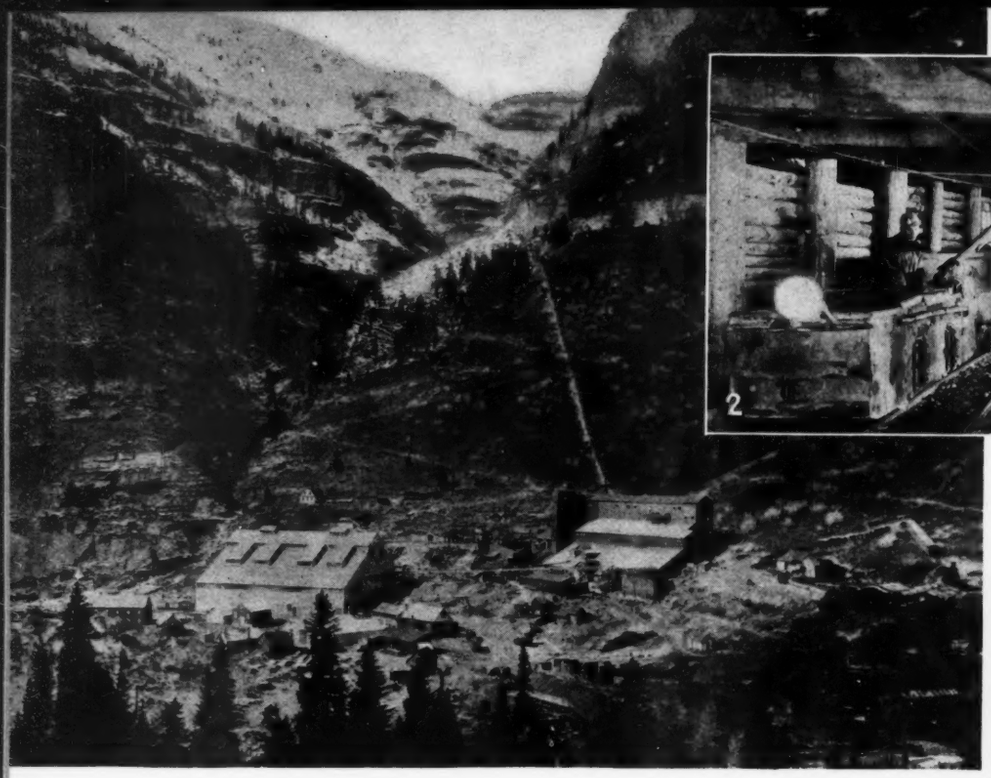
of the sediments and generating an additional supply of heat. This problem of heated water and gases is a considerable obstacle to deep mining within the laccolithic domes of the ancestral mountains.

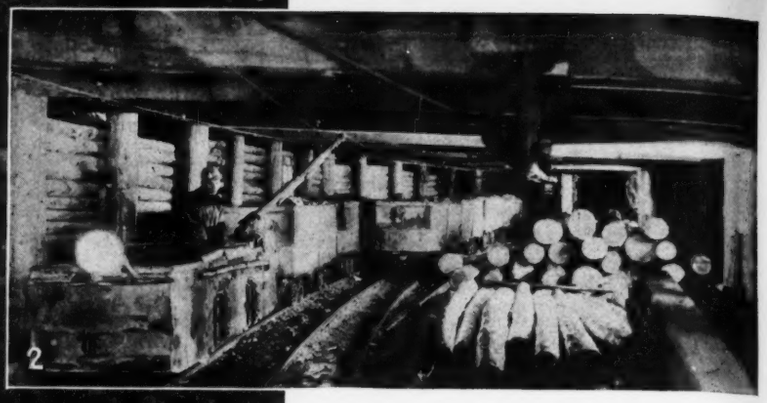
Geology as a guide to the finding of additional centers of mineralization, perhaps concealed beneath the later cover of volcanic rocks, is admittedly less hopeful. That some of the older veins at Ouray have been so concealed is proved by their re-exposure after erosion of the volcanic rocks from their early Tertiary outcrops. The application of geophysical methods to the tracing of covered veins or to the finding of concealed deposits does not yet appear very hopeful, because of the immense increase in the size and differences in physical properties required of the orebodies for their successful detection with increasing depth. Diamond drilling is of some use in future exploration for concealed deposits or for obtaining geologic information beneath the volcanic cover.

The late Tertiary mountains are carved by erosion out of a large block extending more than 100 miles in a westerly, and about 70 miles in a northerly, direction. The eastern part of this block has been so tilted eastward by crustal movements that a part of it is now deeply buried beneath the San Luis Valley. The western part of the block has been uplifted, and somewhat domed, so that erosion has now exposed many large intrusive bodies and parts of the underlying ancestral mountains. Most of the ore deposits of the San Juan lie in the west part of the block. Their localization has been dominated by such structural elements as centers of volcanic eruption and igneous intrusion, and by major fault or fissure zones. In the eastern San Juan some mineralized districts are grouped about volcanic centers of different ages. In many of them small intrusive bodies are exposed, but in others no large bodies are exposed, though the local structure may be indicative of buried stocks.[7] In the Bonanza district,[8] collapse of the crust about some underlying magma body has largely controlled faulting, fissuring, and mineralization. In the Creede district[9] the principal veins are along a large fault zone in the volcanic rocks, and the form of the reservoir from which the ore-forming solutions came is not apparent.

Probably the largest single structural unit controlling ore deposition is that found centering in the Silverton quadrangle in the western San Juan.[10] The area affected by this structure is from 250 to 300 square miles, and approximately 75 per cent of the total output under Epoch V has come from deposits dependent upon it. The core or hub of the unit is a down-faulted triangular block that represents a volcanic sink or caldera about 8 miles in diameter (see Figs. 3 and 4). Most of the dikes and veins in this area are arranged radially about this block like the spokes of a wheel, though a few are concentric and parallel to its margins. Several intrusive igneous bodies are grouped around the margins of the block and in outlying positions 5 to 8 miles from the margins. Radial fissures connect these outlying centers of intrusion with the central block. The distribution of the different kinds of ore shows that zoning is outward from the central structure and more or less independent of the exposed igneous bodies.[11] Completion of geologic mapping of this unit will permit more systematic exploration of portions of the structure that have not been developed, and will permit forecasts of the kind of ore to be expected. Much research remains to be done, and the San Juan region offers unusual opportunities to correlate types of fracturing and fissuring with the physical properties of the rocks. This research invades the field of geophysics, but offers hope of further development of geology as a guide in ore hunting.

In conclusion, the future of geologic investigations in the late Tertiary San Juan Mountains would seem to lie in detailed structural surveys for the purpose of recognizing and delimiting all of the major structural units controlling the distribution of ore deposits, and in determining principles of rock fracturing that control the localization of individual oreshoots. This field of service is necessarily that of State or Federal surveys, since the areas to be covered are large compared to the operations of mining companies. The use of geology in controlling individual operations must, to some extent, depend upon basic principles and major controls outlined by these broader field studies, but the problems of each operation are much more complex in detail and many of them will require local intensive appli-





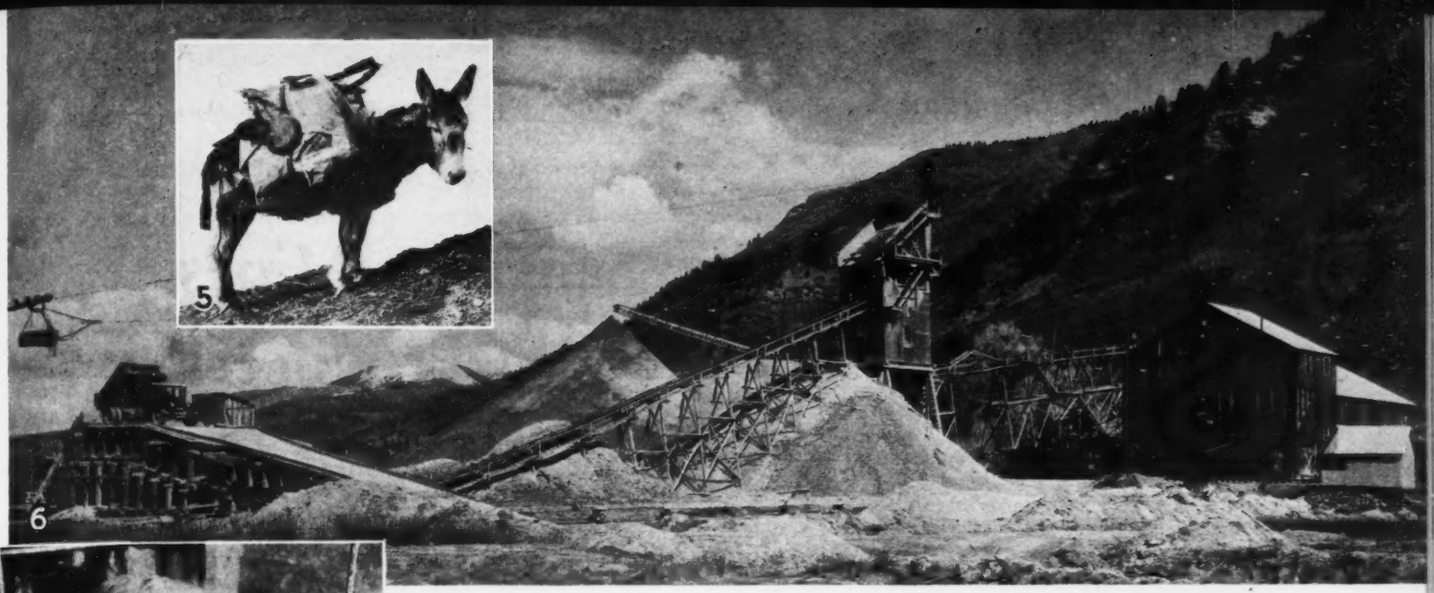
N THE
SAN JUAN

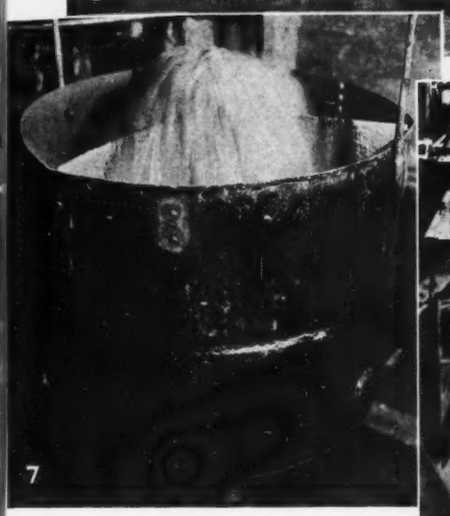
1 **A FAMOUS VIEW** at Telluride. Mill buildings of the Smuggler Union, now operated by the Telluride Mining & Milling Company, which buys and concentrates all ore mined in its workings by lessees

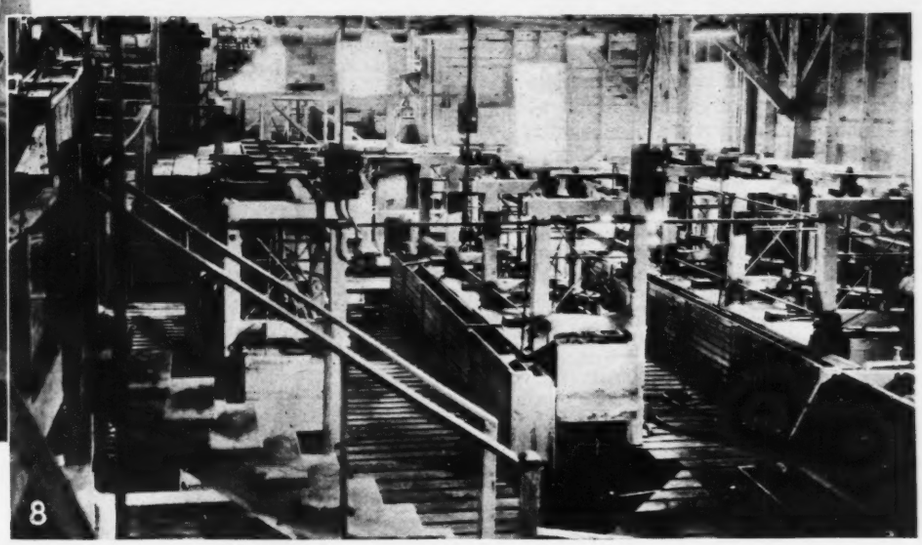
2 **HAULAGE** in the Smuggler mine. This 4-ton electric locomotive, of two-motor tandem type, pulls three cars at a time from the Penn workings

3 **DRILLING** with a self-rotating stoper on the 450 level of the Shenandoah-Dives mine, near Silverton

4 **CONCENTRATOR** of the Shenandoah-Dives company, 2.5 miles from Silverton. Designed originally to handle 300 tons daily, its capacity has been increased progressively to 600 tons, and with improvement in recoveries







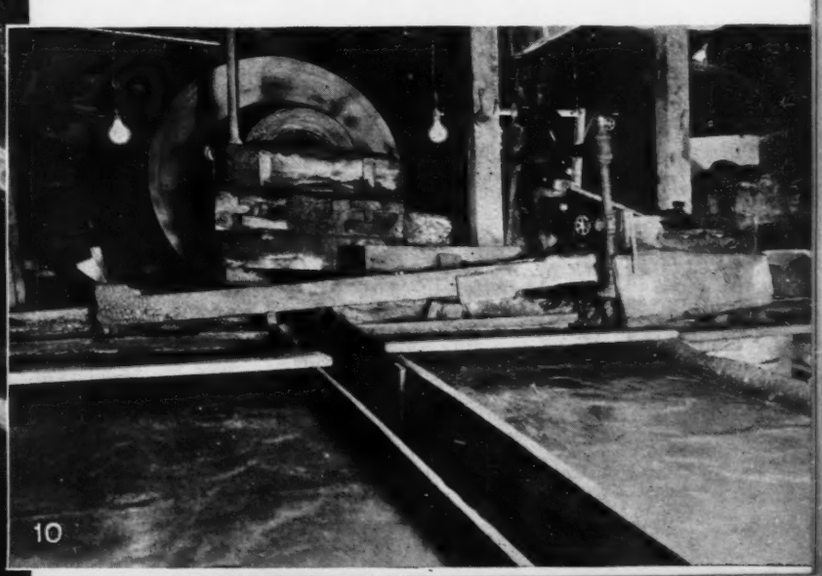
5 THE BURRO—mellifluous songster of the night—is still of service in the San Juan

6 CONCENTRATOR and dragline equipment of the San Juan Metals Corporation, east of Telluride

7 OF UNUSUAL DESIGN is this three-way distributer in the San Juan Metals plant

8 THREE FLOTATION MACHINES in the mill of the San Juan Metals Corporation

9 SHRINKAGE STOPING is used in the Camp Bird mine, now operated by King Lease, Inc., at Ouray. Here, long stulls have been put in for support while cleaning down the stope



cation of geologic study by the mining companies. The greater part of the production of the western San Juan comes from centers belonging apparently to one age of igneous and volcanic activity, but the occurrence of deposits clustering about small centers of activity of different ages in the eastern San Juan shows that all deposits are not of the same age. At present the question cannot be answered as to whether or not strictly epithermal deposits of the younger lavas in the eastern San Juan will pass in depth into the higher temperature "leptothermal" types as exhibited by the zoning of the western San Juan.

The concentrations of vanadium and uranium in the San Miguel Valley just west of the San Juan uplift, and placer concentrations of different erosion cycles, have not received attention in this article, but offer further opportunities for the application of geologic and geophysical investigations to their future development.

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Active San Juan Mines Include Old Producers

Camp Bird, Smuggler Union, and Shenandoah among them—Shrinkage, cut-and-fill and open stoping practiced—Operating conditions difficult

Charles N. Bell
Managing Director
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Ouray, Colo.

THE history of the Camp Bird mine, in the Ouray district, discloses it to be one of the most successful financial gold-silver mining enterprises in Colorado. Present operations are carried on by the King Lease, Inc.

In this mine the vein is a fault fissure intersecting the San Juan tuff and andesite. It is a compound vein from 2 to 30 ft. wide, averaging 5 ft. There are approximately 15 miles of underground workings. The vertical range of exploration extends from 2,300 to 3,000 ft. below the outcrop.

Camp Bird's upper workings are entered through a 2,100-ft. crosscut joining the surface mill bins with the main haulage drift on the Camp Bird vein. The portal is 11,300 ft. above sea level. The most productive horizon extends from the crosscut level to 11,880 ft., although one oreshoot extends to 12,350 ft. and another as low as 10,500 ft.

Shrinkage stoping is used. Present practice is to drift on the vein at vertical intervals of 150 ft. When in commercial ore, the drifts are back-stoped to a height of 12 ft.; stulls and lagging placed and stoping operations started. Chutes are built on 20-ft. centers and manways on 150-ft. centers. Each manway consists of a ladderway and timber slide with lagging nailed on the stope side of the stulls. Manways are equipped with Little Tugger air hoists and skips for handling tools and timber. In the event ore does not extend to the level, chute raises are driven. The interval between these depends upon the height of the ore above the level. For a height of 15 ft. the spacing is 20 ft. Chute raises are connected by 45-deg. inclines. Stoping is done with Gardner-Denver Model 77H automatically rotated stopers, and drifting with Gardner-Denver Model 107 drifters.

Stoping is started with a cut round, thus forming a face. Steeply inclined holes are drilled so that the round breaks to the face. Holes are spaced depending on the ground, care being taken in pointing them to avoid breaking the hanging. Stope backs are kept flat.

Absence of gouge or other binding material in the vein permits a simple operation in drawing old fills without remining. They are drawn through sorting stations built over ore passes to the main haulage level and contiguous to empty stopes. The fines pass through an inclined grizzly which feeds to a flat grizzly. Coarse ore is broken through the flat grizzly to join the fines.

At present costs are based on operations of 75 tons a day exclusive of Federal taxes and royalty. Per ton, they are as follows: Mining, $2.19; development and deadwork, $0.94; milling, $1.45; shipping and selling, $2.07; maintenance and repairs, $0.49; general, $0.58; and local taxes, $0.20.

Freighting involves haulage of 6 miles by teams and 2 miles by pack. The difference in elevation is 3,600 ft., costing $1 a ton-mile up and 75c. a ton-mile down. Power cost based on an average load is $8.95 a horsepower a month.

Four miles north of Ouray is the property operated by the Banner American Mining Company. The veins are fissures in sediments. Present production is from the Pony Express vein. Development of the Bachelor vein is under way.

The Pony Express vein is nearly vertical, dipping about 80 deg. Where it breaks through the Pony Express beds, it is deflected along the flat bedding for a distance of 130 ft. before it again takes its normal dip. The miners call this deflection a "roll."

Mining methods used on the vertical sections of the veins are shrinkage stoping and open stoping with stulls. For example, one vertical section is mined by open stoping with stulls; the back is drilled from lagging placed on the stulls. The vein flattens above the open stope, which is 70 ft. high, and the

flat section, about 20 ft. high and 130 ft. long, is drilled with drifters and the broken ore moved to the open stope with a scraper and hoist. Beyond this flat section, the vein "rolls" upward again, and this vertical section is mined by shrinkage, the ore being pulled through a chute, trammed across the flat stope, and dumped into the open stope. The block mined by shrinkage is about 85 ft. high.

A sublevel is driven from the top of the shrinkage stope with chute raises at 25-ft. centers, and an open stope with stulls is then started. Manways are placed on 100-ft. centers. Ore is trammed into the shrinkage stope. Ingersoll Rand N75 drifters and R51 automatically rotated stopers are used in mining the ground, and 40 per cent Du Pont gelatin.

Hand tramming is used on the sublevels and mules on main haulage levels, although mules are being replaced by Atlas 2-ton storage-battery locomotives. Atlas 1-ton side-dump and Truax 1-ton end-dump cars are used.

The mine is now operating one shift and producing 40 tons of ore averaging 0.02 oz. gold, 17 oz. silver, 1½ per cent lead, and 1 per cent zinc. Production will be increased to 200 tons a day during the year.

Power is generated by a 500-hp. Busch-Sulzer diesel engine direct connected to a 400-kva. Westinghouse alternator at 2,300 volts, which is stepped up to 10,000 volts for distribution. Power cost is 1.1c. per kilowatt-hour.

Ore is transported from the mine to the mill with trucks, a distance of ¾ mile, and supplies are returned to the mine, for 23c. a ton. Operating costs are: Mining, $1.62; development, $0.62; milling, $1.15; general, $0.38; taxes, $0.07; and marketing, $0.80.

In the Telluride district the producing properties are the Smuggler Union mine, operated by the Telluride Holding Company, and the Gold Run placer, worked by the San Juan Metals Corporation. The Black Bear mine has been purchased recently and may be worked soon. Ore is developed and ready for mining, but a mill is needed. The Alta is said to be under option.

At the Smuggler Union all ores are mined by lessees and are sold to the company on a sliding scale based upon grade. The schedule is arranged to discourage the production of low-grade ores. The mine is entered through the Pennsylvania tunnel, at an elevation of 10,000 ft. This follows a vein which intersects the Smuggler Union vein on the lowest level.

As the ore grade is so vital to the lessees, shrinkage stoping has given way in most cases to a cut-and-fill method locally known as the flat-back waste-fill system. Shrinkage will be used in some new sections.

At present all work is above the Pennsylvania level and confined to two veins. An andesite breccia contains the principal orebodies, though ore is found in other formations. The vein has been explored for 7,000 ft. and a vertical height of 2,000 ft. Stoping is practically continuous on the Smuggler Union vein in the Smuggler Union property, and extends into the Humboldt property to the north.

The veins dip 70 to 80 deg. and vary in width from 18 in. to 12 ft. In some places the walls are good; in others poor.

The drift on the vein is back-stoped and timbered, either by stulls or square sets, lagging is placed and stulled manways are started, the number depending on the stope length. Chutes are placed at 50-ft. intervals. A 20- to 50-ton ore pocket is built over the chute, and mill holes, leading from the pocket up through the fills, are built from waste rock, one wall being used for a side of the hole. In narrow veins both footwall and hanging wall are used for sides of the mills. A satisfactory size for the mills is 24x24 in.

HEAVY SNOWFALL in San Juan region makes transportation difficult. Sacked concentrates are shipped, via mule-back, down the mountain and necessary supplies are carried on the return trip

A light round is first shot on the lagging to avoid breakage, the lagging having been covered with waste. The stope is started with a round similar to that used in a raise to obtain a face. The vein material is broken and the pay ore sorted and shoveled into the mill holes; the material below pay grade is left for fill. Additional fill, if needed, to bring the top within working distance of the back, is shot from the footwall. The muck is leveled and a floor made before the vein material is shot. The latter is shot directly on this floor. If the pay streak is narrow, the same procedure is followed except that the ore is stripped. The advantages of this method, in addition to giving clean ore, are safety and capacity to withstand excessive wall pressure. Principal disadvantages are loss of rich fines and the difficulty in keeping mill holes open.

The method that will be used in mining stope fills will be to spile through them, making drifts. The talc and gouge in the veins, together with the pressure from the walls, have formed a mass that can be mined in the manner of virgin ground except that, where blasting is necessary, a sharp steel is driven in the fills with a single jack instead of using air drills. If empty stopes are available for waste disposal, the fills will be mined by shrinkage and all material passed through sorting stations. Otherwise, a method similar to cut-and-fill will be used.

Drills used are Ingersoll-Rand R51 automatically rotated stopers. Round native timber is used; also Du Pont 40 per cent gelatin. The steel is 1-in. quarter octagon.

At present the mine is producing 150 tons a day, which will be stepped up to 200 tons during the year. A shaft 250 ft. deep to explore the downward extension of the oreshoots will be started soon.

The Rico district is 25 miles southwest of Telluride. Most of the mining is in nearly vertical fissures which cut across the bedding planes of the sedimentary series, and in replacement deposits in limestone. Prospecting is difficult and expensive, due to the complicated geology, and mining is carried on under various methods.

The fissure veins are mined by two methods: Where the values are high, such as in Newman Hill, filled stopes are used. The ore is stripped, shot on boards or on boards over canvas, sorted, and the low-grade material left in the stopes. Vein widths vary from 6 in. to 2 ft. The narrow portions usually are richer than the wide ones. The ore is direct-smelting.

Where the values are on the border line of milling-shipping grade ore, a shrinkage system is used. Care must be exercised to maintain a certain grade. In some cases sorting is done at the surface.

Ore deposits resulting from replacement of limestone by lead-zinc-copper ore are mined by a room-and-pillar method. After the bulk of the ore is removed, the pillars are mined. The extent of the initial operation depends on the roof. If the roof is hard sandstone, the greater part of the ore is taken the first time. With a shale roof, stulls and headboards are used and the ore recovery is less the first time through. In these bedded deposits, after

the extent of the orebody is determined, mining is started at the lower end to obtain the advantage of gravity for tramming. Where necessary, sorting is done in the stopes.

The division line of the various grades of ore is definitely marked, and little difficulty is had in segregating the classes of ore.

At Silverton, the Shenandoah-Dives consists of seven claims covering 8,100 ft. along the strike of two vein systems known as the Mayflower and Shenandoah. Four of these claims had made important prior production, but until consolidation was effected in 1925 no well-planned concerted action had been taken toward working the mines as a unit.

Soon after consolidation, development was started on the old Shenandoah mine, on the Cunningham Gulch side of the mountain. Subsequently, operations were transferred to the new Mayflower portal, in Arrastra Gulch, which empties into the Animas River. It is at an elevation of 11,200 ft., which is 1,100 ft. lower than the original camp. The mine hotel, timber shed, and tram terminals are the only surface buildings; the shops, compressors, and crushers are underground.

When mine development had reached a satisfactory stage, the Iowa mill, below the camp, was leased and rehabilitated into a pilot mill. An aërial tramway conveyed the ore to the mill. A new mill was built when a satisfactory plant-scale flowsheet had been determined. The initial capacity of the mill was 300 tons per day, but with a few changes it was raised to 600 tons.

The Mayflower vein occurs in the Eureka rhyolite, whereas the Shenandoah vein is found in the Burns latite. Different types of base-metal ores with important amounts of gold and silver are found in the 2,300 vertical feet of mine development. The Mayflower vein is in the north end of a 3-mile normal fault fissure. Near the Mayflower mine portal, in Arrastra Gulch, are precipitous walls in the rhyolite and latite flows. An andesite dike ranging in width from 6 to 50 ft. has been injected along the fault. The dike has not pushed through the whole series of volcanic rocks, but irregular lenticular orebodies have been formed in the veins. The main deposits are rarely as wide as the shattered part of the dike, and they dip about 65 deg. northwest.

The vein filling is quartz with pyrite and chalcopyrite, but includes quartz-seamed rhyolite and less altered rhyolite containing pyrite and chalcopyrite, which is often rich in gold. The massive Eureka rhyolite is of a friable character and easily shattered. When such shattering occurs close to the andesite dike, quartz-chalcopyrite ore is found. In general the dike is on the hanging-wall side of the oreshoots.

The Mayflower mine is a recent prospecting development in this district, and therefore production from ore found in the Eureka rhyolite has not been great. The results so far obtained, however, have changed the outlook, giving promise of good production of gold and silver without the lead characteristics of the upper workings.

The Shenandoah vein is a compound stringer lode, in some places attaining a width of 100 ft. It occurs in the upper Burns latite flow and tuff member, and outcrops about 4,000 ft. southeast of the Mayflower mine portal. It is apparently in the hanging wall of the Mayflower vein. The Mayflower dike is not present in the upper workings.

In the early days of the mine extremely rich silver ores were mined close to the surface. Tetrahedrite with a high silver content occurs in the branching stringers of quartz. The oreshoots also contain galena and pyrite.

The vein may be offset by steep faults at small acute angles to the main sheeted zone. Post-mineral movement along the main fault had produced false continuations of the veins. These were then mineralized by later and weaker solutions. The quartz and sulphide vein filling of the high-grade type passes gradually into vein material of barren quartz, gouge, and calcite. This is likely to be mistaken for a pinch in the orebody when in reality the vein has been faulted to the north.

The main adit is 4,850 ft. along the strike of the Shenandoah vein. Upper levels are spaced 150 ft. vertically, with main raises every 100 to 200 ft. along the vein and a man-and-material skip with hoist at a convenient point operating to the 750 level. The main level drift is 8x9 ft. in the clear; the upper levels are 6x8 ft. Manway raises are between two chutes and a 5x6-ft. timbered ladder-and-material-slide compartment.

To date the mine has produced better gold ore in the rhyolite along the main level and extending upward in places as far as the 300 level than elsewhere. This same formation occurs below the main level. Recently, on looking into the rhyolite area below its lowest levels, the company has found there the best concentration of metals in the history of its work. The rhyolite continues indefinitely below and present emphasis is placed by the management on development in it at depth.

In January, 1935, a poor hanging wall on the 600 level was diluting the ore mined by shrinkage stoping. The method was changed to horizontal cut-and-fill, stull timbering, and some shrinkage, in areas with sound walls. Stoping is performed with Ingersoll-Rand R51 drill; drifting drills are Gardner-Denver D89. Both Timken and Ingersoll-Rand detachable bits are in use. Diamond drilling is done with Mitchell-Chicago-Pneumatic drills.

The method of mining for each stope is determined as work progresses. One system cannot be adhered to in all cases.

The present transportation plan is to place a gathering motor on the 600 level to handle all ore broken above this level and below the 900 level and deliver it to one direct ore pass to the main level. On the main level the ore is motor-trammed to the coarse-ore bin, where a C.S. Card rotary dump handles two cars at a time. An adaptation of the McIntyre-Porcupine chutes is in use with a 4x5 ft. opening.

For main haulage two Goodman battery locomotives, of 8½ and 4 tons respectively and equipped with Edison storage batteries, are used. The train is made up of twelve 63-cu.ft. round-bottom cars. The 300 level haulage consists of a General Electric 3-ton battery locomotive handling three and four 70-cu.ft. side-dump cars. This type of equipment will be duplicated on the 600 level, but using Granby cars and dump in place of the present air-cylinder dump used on this level. The Base Level haulage, delivering crushed ore to the aërial tramway, consists of a Goodman 3-ton storage-battery locomotive and three 100-cu.ft. gable-bottom cars. This locomotive is of the storage-battery type, but is charged continuously by using a trolley. Ore haulage tracks are 30-in. gage.

Compressed air is furnished by a 25x 13x16-in. Chicago Pneumatic compressor. An Ingersoll-Rand Imperial Type 10 unit is a standby. The main air line is 8-in. casing and secondary lines are 4-in. casing, all using Dayton couplings. Occasionally, standard 2-in. pipe is used. These large sizes of air lines hold a generous storage.

Mine drainage is no problem, as the main level drains all stoping areas.

Costs obtained under the difficult San Juan operating conditions over a two-year period, 1933 and 1934, when milling 408,252 tons, or an average of 204,-126 tons of ore a year, were: Mine development, $0.33; other mine expense, $1.66; aërial tramway, $0.105; mill, $0.77; and overhead, $0.095. Total, $2.96. The average wage for 1933 and 1934 was $4.92.

Flotation Widely Employed In San Juan Milling

Amalgamation also used at some plants, and rubber mats at one—Custom treatment planned by Shenandoah-Dives

Charles A. Chase
General Manager
Shenandoah-Dives Mining Company
Silverton, Colo.

IN THE SAN JUAN AREA of southwestern Colorado, where the operations of some well-known mines have had unusual longevity, no single long-established enterprise is to be found today. Nevertheless, some of the newer undertakings offer the promise of prolonged life. The oldest of these was started no later than 1917, since when seven companies worthy of consideration have come into existence. Their operations may be described as follows:

One of the newest, if not the most recently organized, is the San Juan Metals Corporation, which purchased the holdings of the Gold Run Mining & Milling Company, east of Telluride, early last spring. These consisted of a 250- to 300-ton flotation plant, together with a Sauerman dragline equipment for reclaiming tailings and for placer work and a ten-year lease on the Gold Run placer, between Telluride and Pandora. This tailing deposit resulted from operations at Smuggler Union, Liberty Bell, Tomboy, Cimarron, and Ajax properties. Recoverable tonnage amounts to more than 400,000.

Before the company began work last year a ramp was built, with incline conveyors for delivering the reclaimed material to the mill in its original dry condition. Numerous changes were made in the original flowsheet, and operations were started June, 1934, and continued until Nov. 27. Approximately 48,000 tons of tailings was re-treated. During this work, the river gravel was found to have much better values in the finer sizes than the straight tailings, so, before operations were resumed this spring, a portable dry scrubbing and screening plant was installed. This plant has a 4x4-ft. scrubbing section followed by a 4x10-ft. trommel screen having ⅝ x 1¼-in. openings.

Material is delivered by a half-yard General Excavator gas-driven power shovel. The minus-⅝-in. material is delivered to 3½-cu.yd. International Dump trucks by a 24-in. conveyor and hauled to the ramp. The plus-⅝-in. material discharges onto a 24-in. swivel stacking, or tail, conveyor. At the ramp the minus-⅝-in. material, which averages approximately 33 per cent of the original gravel in place, is fed onto a 16-in. incline conveyor by means of a 36-in. steel pan feeder, driven by a 5-hp. U. S. Vari-speed motor, which permits varying the volume of feed. The material goes to two Traylor vibrating screens having ¼x½-in. openings. Oversize averages approximately 10 per cent of the original material in place, so that the actual amount of minus-¼-in. material delivered to the mill is 23 per cent of the total. The minus-⅝-in. plus-¼-in. screened oversize is washed in a 54-in. single submerged-type Akins classifier, the overflow going into the mill circuit and the washed gravel or classifier sand discharging to waste.

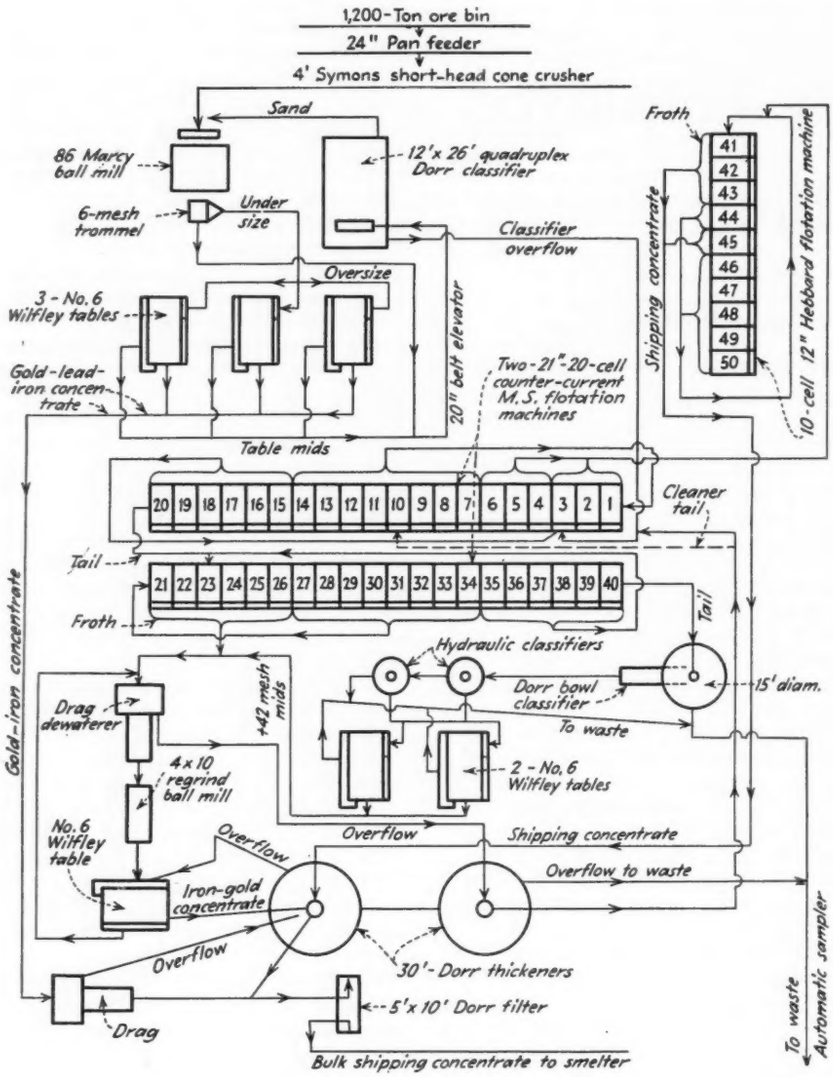
The minus-¼-in. dry undersize from the screens is sent to a stockpile, from where it is fed onto a belt feeder by gravel boards, and goes to a 7x5-ft. Marcy ball mill. The rate of feed averages 250 tons of minus-¼-in. material per 24 hours, and is controlled by a 3-hp. U. S. Vari-speed motor. Ball mill discharge goes to one No. 500 Denver Sub A unit cell, making finished concentrate. The spigot discharge of the unit cell goes to a No. 11 Wilfley table and the tailings of the cell go to three No. 11 Wilfley tables. All tables produce a finished concentrate and middling tailings. These are elevated to a 6x22-ft. duplex classifier, from which the sand goes to the ball mill.

Classifier overflow, averaging 12 per cent plus 100 mesh and 25 per cent solids, flows to one 8x8-ft. conditioner tank and thence to the No. 2 cells of three 18-in. six-cell Fahrenwald flotation machines operating in parallel. The concentrates from cells 2 to 6 inclusive return to No. 1 cell, where a finished concentrate is made and a cleaner tailing, which joins the feed to the No. 2 cell. The tailings from all three Fahrenwald machines are combined and retreated in two 12-ft. air-lift type Shimmin-Hirsch machines in series. Concentrates from these are returned to the conditioner tank by a 2-in. Wilfley pump. The tailings go to waste. Mill heads, combined general concentrate, and general mill tailings are sampled automatically. The combined table and flotation concentrate is pumped to a 4-ft. hydraulic cone by a 2-in. Wilfley pump; the spigot product flows to two filter-bottom steel concentrate bins; the overflow goes to one 20-ft. Dorr thickener, which overflows to waste; and the underflow to one 6x8-ft. Oliver filter. By separating the combined concentrate in this manner the spigot product averages approximately 60 per cent of the total production. This material, in which lead predominates, is shipped to the Leadville smelter. The overflow predominates in copper and averages approximately 40 per cent of total production, and is shipped to Garfield, Utah. Average ratio of concentration is 25 into 1.

The corporation acquired an option to purchase the Treasury Tunnel mine, in the Red Mountain district, near Ouray, last year. This mine was then opened up and the Handicap vein was sampled and found to contain a large body of low-grade ore. The company plans to develop it further. Frank Eichelberger, vice-president of the Sunshine Mining Company, at Kellogg, Idaho, is president and H. B. Van Sinderen, vice-president.

The Shenandoah-Dives Mining Company, which has a concentrator 2.5 miles northeast of Silverton, has milled continuously from June, 1928, first with the Iowa-Tiger plant, and from February, 1930, with its own plant. Bulk flotation is practiced, some pyrite and sphalerite being depressed and wasted. The mill was designed for 300 tons daily; but, with lowering grade of ore and lowering prices of metals, capacity was increased progressively to 600 tons, this final capacity being assured by the interpolation of a 4-ft. Symons shorthead crusher operating wet at the ball mill. Metallurgical results held uniformly good as tonnage mounted, extractions at 600 tons being 91.1 per cent for gold, 83.9 for silver, 87.5 for lead, and 88.2 for copper, compared with 90.8 per cent for gold, 84.2 for silver, 86.2 for lead, and 89.5 for copper at 300 tons.

This result is the more striking in that the gold and silver content of the ore was nearly a third lower when tonnage reached the higher figure. Explanation is found in the tabulation of screen analyses, which show progressive decline in percentage of total ore crushed to pass the 200-mesh screen. Overground sulphides are not floated successfully. At the higher tonnages the growing losses in coarse oversize failed to offset the gains incident to avoidance



SHENANDOAH-DIVES uses this flowsheet in its mill, near Silverton. Capacity is 600 tons per day. Bulk flotation is practiced, some pyrite and sphalerite being depressed and wasted

of overgrinding at the other end of the scale. Temporarily, the mill battles less successfully with oxidized ores. The tonnage is lower for the time, and again overgrinding is reflected in losses in the fine sizes.

Operations are shown in the flowsheet. The ore is crushed in two stages within the mine before delivery to the aërial tramway, the machines being a 16-A Telsmith and a Symons cone, with a Traylor screen above the latter. Ball consumption is 1.75 lb. per ton, and classifier speed 30 strokes per minute. Reagent consumption per ton of ore is: Hercules Middol, 0.055-0.141 lb. (varying inversely with the tonnage); Great Western amyl xanthate Z5, 0.02-0.034 lb., varying similarly; Minerec B, 0.041-0.016 lb., used alternately with Houghton 75 per cent sulphonated castor oil, 0.0016 lb.; and hydrated lime, 0.2-0.76 lb., varying markedly with oxidation. T. R. Hunt has supervised milling work throughout.

King Lease, Inc., has returned the famous Camp Bird mine to active production under the management of Charles N. Bell. The mill is 8 miles southwest of Ouray, near the upper portal of the mine, at 11,311 ft. above the sea. The ore milled is quartz and silicified andesitic breccia with gold, silver, galena, chalcopyrite, pyrite, and sphalerite. Milling is handicapped by the scarcity of water.

Ore is brought from the mine in 1¼-ton cars, weighed, dumped over a grizzly having 1½-in. openings, and shoveled into a 9x16-in. Cedar Rapids crusher directly above the ore bin. The grizzly undersize joins the crushed ore in the bin, from which it is fed by Challenge feeders and conveyed into the two ball mills. These are in parallel, one being a 5x4-ft. Marcy and the other a 4½x4½-ft. tire-and-trunnion overflow type. The efficiency of the Marcy mill is so much greater than that of the overflow type, though the sizes are nearly equal, that the latter should be discarded. Both are in closed circuit with a Dorr Simplex classifier, the overflow from the classifier going, in turn, to amalgamation plates, quicksilver traps, a launder containing a 1-mesh screen over a sponge rubber mat, thickener, conditioner, flotation, and filter.

Care is taken not to have any oils and flotation reagents contact the plates. Despite experience of others to the contrary, whenever the combination of xanthate, hardwood creosote, and pine-oil touches the plates, trouble is had with amalgamation. For this reason a unit cell is not used between the ball mills and the classifier. The gold that accumulates in the latter and on the ball mill liners is recovered when the liners are replaced.

The three plates nearest the classifier are dressed seven times in 24 hours and cleaned once. The following set of three plates is dressed three times in 24 hours and cleaned once every third day. Seldom are chemicals used in dressing the plates. The results obtained with amalgamation following ball milling are said to be as good as those formerly had following stamps. Assuming that the latter were due to the wave action caused by the stamps, the management approximated that wave action, when using ball mills, by placing the plates immediately below an old-style Dorr classifier which discharges the pulp in successive pulsations. Mercury consumption is 0.014 lb. per ton.

Cast-iron liners made by the Telluride Iron Works, of Durango, are used in the overflow mill in conjunction with 4-in. forged-steel balls. Moly-chrome feed end liners and manganese-steel shell liners are used in the Marcy mill with 5-in. forged steel balls. Ball consumption is 2.81 lb. per ton.

Flotation reagents used are 0.1 lb. xanthate Z5, 0.1 lb. xanthate Z8, 0.042 lb. Cleveland-Cliffs hardwood creosote No. 1, and 0.042 lb. Yarmor F pine oil, per ton of ore. Depressants for sulphides of iron and zinc have been discontinued for the present, due to increased loss of gold.

Ratio of concentration is 11.6 to 1. Mill heads run 0.39 oz. gold, 4.0 oz. silver, 0.85 per cent copper, and 1 per cent lead. When milling freshly mined ore, the recovery is: 90.2 per cent gold, 86.3 per cent silver, 97.2 per cent lead, 92.1 per cent copper. When very old stope fills are mixed with freshly mined ore to the extent of 50 per cent, the recovery will drop as much as 5 per cent. Amalgamation yields 64.3 per cent of the gold and 2.4 per cent of the silver marketed, and 35.7 per cent of the gold and 97.6 per cent of the silver are recovered by flotation.

Costs apportioned to milling exclusive of Federal taxes and royalties are: Mill-

ing, $1.45; shipping and selling, $2.07; maintenance and repairs, $0.294; general $0.29; local taxes, $0.10. (Mining, $2.19; development and deadwork, $0.94; maintenance and repairs, $0.916; general, $0.29; local taxes, $0.10). Of the milling cost 40 per cent is for labor and 60 per cent for supplies. These are based upon 75 tons a day.

Power cost based on the average load is $12 a kilowatt a month. Cost of hauling concentrates 2 miles by pack mules and 6 miles by teams, in a descent of 3,500 ft., is 75c. a ton-mile.

At Ouray, the Banner American Mining Company, G. A. Franz, president, operates a modern 75-ton flotation mill on the Pony Express and other claims of the Bachelor vein system, highly productive in pioneer days. The property is more distinctly a silver mine than any other in the region, but has some lead. The silver occurs in part as bromide, and the concentrate is notably high grade. The plant is unique in being diesel-powered, a 600-hp. Busch-Sulzer engine being used.

The Telluride Mining & Milling Company carries on the operation of Smuggler Union mine, that greatest producer of the whole San Juan region. D. E. Harrison is vice-president and general manager, Philip Washer, secretary, and C. F. Dandois, mill superintendent.

From the aërial tramway bins at the crushing plant, the ore is delivered to the mill by the tram in half-ton buckets at the rate of 70 buckets per hour. These are dumped into steel fine-ore bins of 250 tons' capacity each. From the bins the ore goes via a cone, a roll feeder, and a short conveyor belt to a 7x6-ft. Allis-Chalmers ball mill, which handles 250 tons a day. Its discharge passes over crepe rubber mats to an elevator and again over crepe rubber mats to a Model D Dorr duplex classifier. Oversize is returned, and undersize sent to flotation. The amount of gold and silver bled from the circuit by the rubber mats is about 25 per cent of the total recovery.

The classifier overflow goes to the flotation plant, where it is conditioned and finally floated in locally built pneumatic cells. Concentrates are recleaned, the middlings are returned to the conditioners, and the concentrate is elevated to a Dorr thickener. The underflow is treated in a Portland filter, the cake being discharged to a conveyor which loads the concentrates into cars.

Reagents used are Aerofloat 25, in the ball mill, G.N.S. No. 5 pine oil in the agitator, and American Cyanamid No. 301 in the cells.

The flotation building houses a complete machine shop and electric shop, where necessary repairs are facilitated.

Six months of the year power is bought from the Western Colorado Power Company and during the rest of the year it is generated on the property with an hydro-electric plant. Mill tailings are impounded and clear overflow empties into the San Miguel River.

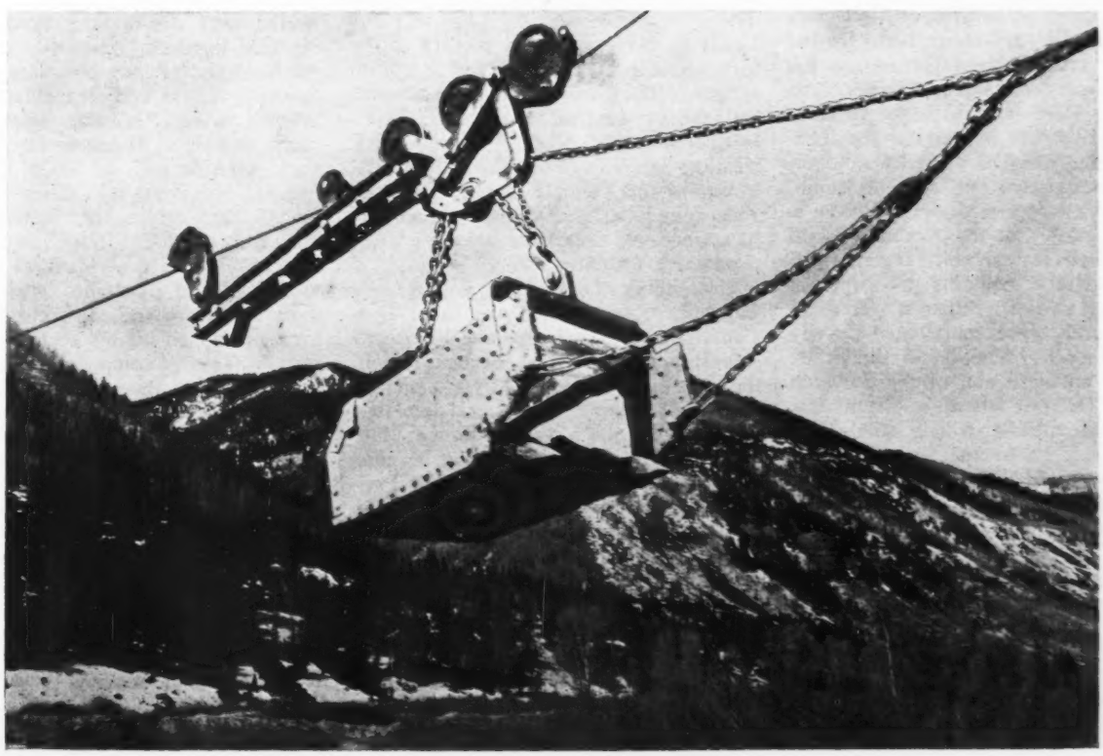
The Sunnyside Mining & Milling Company, a subsidiary of United States Smelting, Refining & Mining Company, which began operations in 1917, holds in the mine itself and immediately contiguous properties what are probably some of the best ore resources of the State. Primarily a zinc-lead mine, the metallurgy of the ore was difficult, but E. L. Young and A. B. Marquand achieved a great success in differential flotation, which Alan Probert subsequently refined. High-grade lead and zinc products were produced. At times a middling was treated in the sulphating plant at Durango, operated by the American Smelting & Refining Company, and at other times a low-grade iron product was shipped. The plant was equipped for 1,000 tons daily and stands ready for operation, the one example in the entire region of established and wholly successful differential flotation.

On the old Mabel mine, 3 miles southeast of Silverton, a small roller mill powered by a Buda engine has been installed by the San Juan Mining Company, F. H. Steelsmith, president. The enterprise marks the rejuvenation of a pioneer property famed for a narrow but rich gold vein.

In lower San Miguel County, near Naturita, the United States Vanadium Corporation prepares for early operation of its extensive vanadium-carnotite properties, under the direction of Blair Burwell. The enterprise is unique in having both its salt and coal immediately at hand.

Custom milling is measurably nearer, the Shenandoah-Dives being now considering the purchase of ores in the near future. Indications are that the provision of such a market will stimulate remarkably the development of the county. Power throughout the entire San Juan is provided by Western Colorado Power Company. The service is reported to be excellent.

THE DRAGLINE BUCKET — here seen as installed for the San Juan Metals Corporation



MINING ON THE

Climax the Outstanding Camp, by Virtue of Its Unique Deposit

▼▼▼

Mosquito and Sawatch Ranges A Distinct Mineral Province

Orebodies of most importance have been found in Ordovician, Devonian, and Mississippian limestones—The manto type most characteristic of this section

Charles H. Behre, Jr.

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WEST of the Front Range in central Colorado are prominent mountains in which important mining camps are located (see Fig. 1). Among these are the Mosquito and Tenmile ranges, the Sawatch or Collegiate Range, and the Elk Mountains. On the flanks of the Mosquito Range are the mining towns of Alma, Climax, and Leadville. Farther north is the Gilman-Red Cliff district, located on the Tenmile Range, which is virtually a northward continuation of the Mosquito Range. West of the Mosquito Range is the broad valley of the Arkansas, with the Sawatch Range still farther west. This range also contains ore deposits, and at least two of its districts, Tomichi and Monarch, have contributed heavily to the mineral production of the State. Near the northern end of the Sawatch Range a separate chain of mountains, the Elk Mountains, trends northwesterly, and on its northern slope is the mining town of Aspen. These districts are in one of the most important mineralized areas in central Colorado.

What follows is intended to serve three purposes: first, to describe recent mining developments; second, to summarize the factors which seem to have localized the distribution of these ores; and third, to outline those parts of the region that are of special promise in view of such favorable factors.

The mountainous region here described has had a geologic history that is too complex for description in a few pages. However, a short account of the more significant facts seems justified.

The Front Range is separated from the Mosquito and Tenmile ranges to the west by South Park, a broadly elliptical depression of remarkable flatness. In the Mosquito-Tenmile Range the rocks are partly Pre-Cambrian and partly Paleozoic in age. In South Park, Mesozoic and Tertiary rocks are preserved. The generalized section (Fig. 2) for Leadville may serve as a picture of the formations in the Sawatch and Mosquito ranges. The formations dip eastward, and are dropped relative to the Front Range mountain group by northward-trending faults in South Park and in the Mosquito and Tenmile ranges. Here the Paleozoic limestones are of special interest because they have been the most productive formations.

Descending the western slope of the Mosquito Range there are basal Pre-Cambrian rocks, which have been considerably faulted. Rock sequence from the Arkansas Valley westward to the Gunnison Valley is in general like that described for the Mosquito Range. The Sawatch Range, however, may be considered a great up-fold in which Pre-Cambrian rocks make up the greater part of the range crest and are flanked on the slopes by Paleozoic sediments. The Elk Mountains are igneous rocks, both intrusive and extrusive, together with Pre-Cambrian granites and schists and Paleozoic sediments.

Intrusive rocks, chiefly of late Cretaceous or early Tertiary age, are common to the important ore deposits. Granite makes up the greatest part of the intrusive bodies. Igneous masses close to the ore deposits favor the interpretation that the ore came from the same sources as the igneous rocks. The intrusive bodies include numerous sill-like masses and dikes, which in many places have had an important influence on ore deposition. These intrusives appear to have "ponded" the rising solutions that carried the ore, thereby causing deposition.

Structurally, the most conspicuous features are the large faults. The most important are reverse faults of steep eastward dip. Their close association with many of the important ore deposits makes it appear that the fractured ground along the faults furnished channelways for the ore-bearing solutions. Mining operations have been complicated by large and small post-mineral normal faults, which have offset some of the orebodies.

Considerable gold ore has been mined along faults and fissures in the Pre-Cambrian rocks of the region. The most important bodies have been found, however, in the Ordovician, Devonian and Mississippian limestones. A few small deposits in limestone are partly fissure fillings and partly the result of replacement of fissure walls. The largest bodies, however, though visibly connected with ore-bearing fissures, have replaced limestone, generally parallel to the bedding, for long distances from the fissures. These bodies are tabular and are commonly "capped" by some less permeable or more chemically resistant rock, such as beds of shale or sills of fine-grained prophyry. They constitute the "manto" type of orebody, well known in northern Mexico and perhaps best typified by the "blanket" or "contact" bodies of Leadville. These are the most important and most characteristic form of deposit in this section of Colorado. Their composition generally changes along the strike, being richer in precious metals and copper near the feeding fissures and in lead and zinc farther way. The mining operations, therefore, yield mixed ores of zinc, lead and silver. Some of the mines are worked for only gold and silver; others produce copper, iron, manganese and molybdenum. Some non-metallics are also produced.

Geologic evidence indicates that most of the important ore deposits originated during the late Cretaceous or early Tertiary mountain-building stage. Ore deposition, though divisible into several

CONTINENTAL DIVIDE

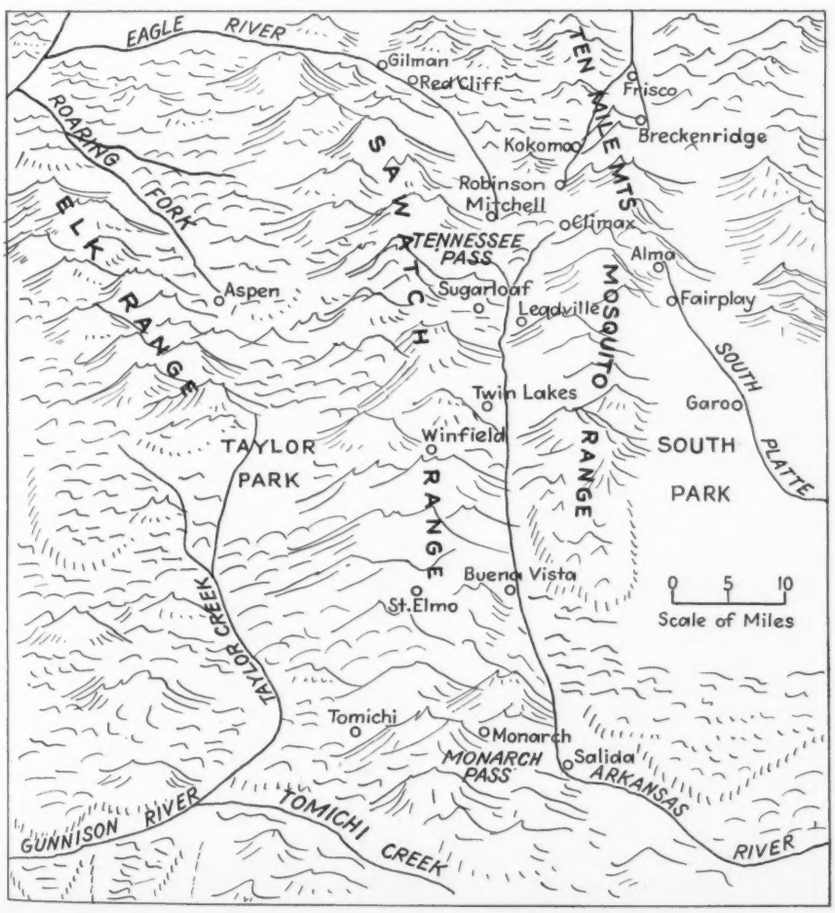
of Molybdenum

distinguishable substages, clearly fell between the folding and reverse faulting that accompanied the Laramide Revolution and the subsequent normal faulting of middle or late Tertiary time.

The old mining camp of Alma is reached most directly through South Park over the narrow-gage line of the Colorado & Southern Railroad. Mining started in 1840, and since that time the district has produced about $20,000,000 of lode ore. In recent years the Alma district has experienced a distinct boom, standing first in Colorado's gold production in 1932 and second in 1933.[1] Gold placers have been worked intermittently for over a century at Alma and near the town of Fairplay, which is 4 miles south of Alma.

At Alma the strata dip about 15 deg. E. from the range crest toward the South Platte.[2] Most conspicuous among the numerous faults are two groups of major thrusts—the London fault and the Cooper Gulch faults (see Fig. 3). The London fault strikes northwest and joins the Mosquito fault, which follows the Mosquito Range near its crest for virtually the entire length of the range. The London fault brings Pre-Cambrian rocks on the east against Paleozoic rocks on the west. In the London mine the gold ore lies along the fault and along tributary fissures in its footwall. Gold and lead-silver ores are present near the Cooper Gulch fault, and silver-lead ores lie along an anticlinal fold on Mounts Lincoln and Bross, a short distance north of the Buckskin Gulch "granite" plug. Near the northern edge of the district there was once considerable gold mining, and in this neighborhood an arrastra, cut in the solid rock, can still be seen.

FIG. 1—MINING CAMPS in the Mosquito, Sawatch, Elk, and Ten Mile Mountains have contributed much wealth to Colorado's diversified mineral production



Of scientific interest, though as yet not of economic importance, are deposits of radioactive minerals in central South Park, near the town of Garo, about 12 miles south of Alma.

North of Alma on the east slope of the Mosquito Range is the famous old mining camp of Breckenridge. Along the Tenmile River, near the town of Frisco and farther north, there are several small, isolated mines in Pre-Cambrian rocks, that have been productive in the past and offer moderate promise for the future.

On the west slope of the Tenmile-Mosquito Range southwest of Frisco are the old camps of Kokomo and Robinson, but aside from recent placering on McNulty Gulch, this region is virtually abandoned. Still farther south, however, at Fremont Pass, is the mine of the Climax Molybdenum Company. The deposit, which is immediately east of the Mosquito fault,[3] is a large mass of low-grade ore, composed of molybdenite in highly altered Pre-Cambrian granite. At present about 4,000 tons of ore is milled daily, supplying most of the world's market for molybdenum, and making this one of the largest metal mining operations in the United States.[4]

The outstanding mining center on the western slope of the Mosquito Range is Leadville.[5] This camp has passed peak production, but several localities are still promising. Most of the ore is found in the "Blue" limestone, which comprises the Dyer and Leadville limestones, of Devonian and Mississippian age. The chief production has been from the famous "blanket" or "contact" deposits, rich in lead, zinc, and silver, most of which have replaced limestones just below sills of igneous rock. In parts of the district, especially near the Breece Hill plug, fractures in different formations have yielded large amounts of gold ore.

In sixty years of exploration at Leadville, the orebodies found near the surface have become fairly well outlined. In the future, however, deeper orebodies may be found in the "White" (Ordovician) limestone on Fryer Hill. The necessary exploration will probably be carried out if the price of silver remains high, but base-metal values alone at existing prices are insufficient inducement.

Gold placering in California Gulch continues on a small scale. Most of the western slope of Breece Hill consists of bleached pyritic porphyry, which, to judge by sporadic sampling, may prove

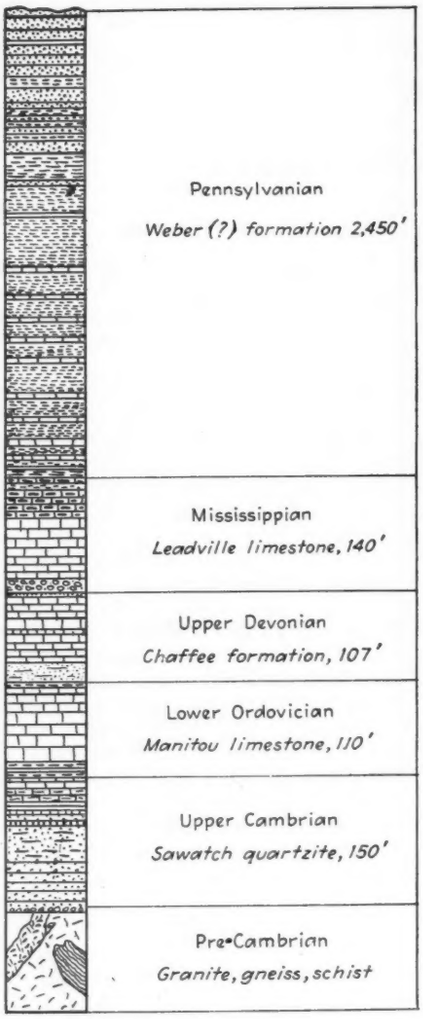


FIG. 2 — GENERALIZED stratigraphic sequence in the Leadville district

to be a low-grade gold ore adapted only for large-scale mining. For treatment of this ore, it has been proposed to construct a cyanide mill in California Gulch at the base of Breece Hill.

Recent developments suggest the presence of ore deposits in the upper part of Evans Gulch west of the Mosquito fault, near the Resurrection, Dolly B., Fortune, and Silver Spoon properties. The first three of these mines are now being operated. The Venir property, on the west slope of Ball Mountain, has been a steady producer of gold ore and may be expected to continue to yield from oxidized fissure veins.

About 25 miles north of Leadville is the town of Red Cliff, where the stratigraphic sequence resembles that at Leadville and the chief ore-bearing horizons are the Devonian and Mississippian limestones.[6] The ore deposits at Red Cliff are similar, both structurally and mineralogically, to those of Leadville, but extensive replacement of beds is less common and smaller, and fissure filling more important. Most of the ore occurs in small bodies parallel to the bedding or where steeply dipping fissures intersect bedding planes or pass from brittle limestone upward into shaly beds, sills, or porphyry. Some rich oxidized ores have yielded native gold and wire silver.

About 3 miles north of Red Cliff is Gilman. Ore is found in all of the Paleozoic formations up to the Permo-Pennsylvanian rocks.[7] The Paleozoic rocks dip northeast and are broken by numerous small steeply dipping faults of northeasterly trend. Small fissures in the Cambrian quartzite were formerly worked for their gold content, but today the chief production comes from orebodies of the "manto" or "blanket" type, resembling those at Leadville and Alma, both structurally and mineralogically. The individual oreshoots are large, one "blanket" measuring 50 ft. in thickness and 75 by 150 ft. in ground plan. The chief minerals are pyrite, galena, and sphalerite. Silver minerals occur in smaller quantities. As at Red Cliff, oxidized ores rich in the precious metals were formerly mined but are now exhausted.

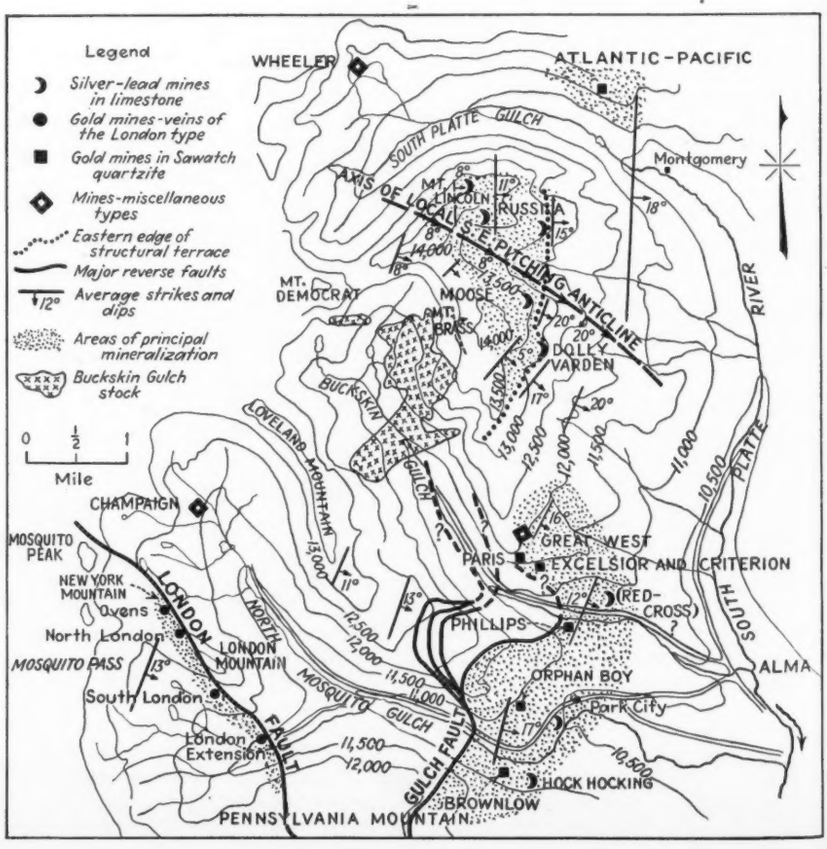
Gilman and Red Cliff together represent a center of mineralization resembling Leadville. Their total production through 1930 is estimated at $3,250,000 in gold, 10,500,000 oz. of silver, 17,000,000 lb. of copper, 110,360,000 lb. of lead, and 247,410,000 lb. of zinc.[8] Future prospecting at Gilman may most profitably lead eastward, and at Red Cliff northward toward Gilman.

The orebodies on the slopes of the Sawatch Range are in general smaller than those of the Mosquito Range. This difference in size is attributed to the shallow cover above the ore-bearing rocks in the Mosquito Range at the time of mineralization, and to the greater susceptibility to shattering and replacement of the sediments. Mining operations in the Sawatch Range are principally for gold and silver.

Near Monarch Pass, 20 miles west of Salida, on both sides of the Sawatch Range, are the Monarch and Tomichi districts. Their ores contain chiefly lead, zinc, silver, and gold. The average tenor for the Monarch district as a whole, according to Crawford, is about $20 to $25 per ton. The orebodies are partly replacement deposits which are preserved on both sides of the range crest in down-faulted outliers of Paleozoic sediments. Much ore, however, occurs in fissures associated with faults. In the Tomichi (White Pine) district, 4 miles west of Monarch, similar conditions prevail.

Other districts in the Sawatch Range

FIG. 3—STRUCTURAL FEATURES in the Pre-Cambrian and Paleozoic rocks, and their relation to the ore deposits in the Alma district are indicated on the sketch presented below, after Singewald and Butler



of minor importance are the St. Elmo, Clear Creek, near Winfield, Twin Lakes, and the Sugar-Loaf-St. Kevin district.

On the western slope of the Sawatch Range, due west of Mount Massive, is Taylor Park. Near its southern end are several gold mines. Among these are the Enterprise, Sevicy, and Wahl mines, which were active on a small scale in 1933 and 1934.

On the northern slope of the Elk Mountains is Aspen. The geology has been recently reviewed,[9] and what follows is largely a digest of that study. Here, too, the most productive formation has been the upper "Blue" or Leadville limestone. It was formerly believed that only two horizons were likely to contain ore, one at the top of the Leadville limestone, the other at a certain horizon within the same formation. Vanderwilt, however, suggests that the structural conditions most favorable to ore deposition are where small faults or fissures intersect the planes separating two lithologically dissimilar formations or members. Recognition of this fact should encourage prospecting along such fissures where they cut any sedimentary contacts characterized by a marked change in the nature of the rock. Examples of such contacts are the base of the Leadville limestone, the top of the Ordovician dolomite, and the bases of the several porphyry sills found in the district. In the last few years the chief production from the Aspen district has been from the Midnight mine, on Richmond Hill.[10]

[1]U. S. Bureau of Mines Minerals Yearbook, 1934, p. 181.

[2]Patton, H. B., Hoskin, A. J., and Butler, G. M.: "Geology and Ore Deposits of the Alma District." Colorado Geological Survey Bull. 3, pp. 1-284, 1912. Singewald, Q. D., and Butler, B. S.: "Suggestions for Prospecting in the Alma District, Colorado." Colorado Scientific Society Proceedings, Vol. 13, pp. 89-131, 1933.

[3]Butler, B. S., and Vanderwilt, J. W.: "The Climax Molybdenum deposit of Colorado." Colorado Scientific Society Proceedings, Vol. 12, pp. 309-353, 1931. Butler, B. S., and Vanderwilt, J. W.: "The Climax Molybdenum Deposit, Colorado." U. S. Geological Survey Bull. 846, pp. 195-237, 1933.

[4]Hess, F. L.: "Molybdenum." U. S. Bureau of Mines Minerals Yearbook for 1934, p. 418, 1934.

[5]Emmons, S. F., Irving, J. D., and Loughlin, G. F.: "Geology and Ore Deposits of the Leadville Mining District, Colorado." U. S. Geological Survey Professional Paper 148, 1927. Loughlin, G. F., and Behre, C. H., Jr.: "Leadville Mining District." Sixteenth International Geological Congress Guidebook 19, pp. 77-91, 1932.

[6]Crawford, R. D., and Gibson, Russell: "Geology and Ore Deposits of the Red Cliff District, Colorado." Colorado Geological Survey Bull. 30, pp. 1-89, 1925. Lovering, T. S., and Behre, C. H., Jr.: "Battle Mountain (Red Cliff, Gilman) Mining District." Sixteenth International Geological Congress Guidebook 19, pp. 69-76, 1932.

[7]Crawford, R. D., and Gibson, Russell: *Op. cit.*, 1925.

[8]Lovering, T. S., and Behre, C. H., Jr.: *Op. cit.*, p. 76.

[9]Vanderwilt, J. W.: "Revision of Structure and Stratigraphy of the Aspen District, Colorado, and Its Bearing on the Ore Deposits." *Economic Geology*, Vol. 30, pp. 223-241, 1935.

[10]Knopf, Adolph: "Recent Developments in the Aspen District, Colorado." U. S. Geological Survey Bull. 785, pp. 19-28, 1926.

Climax—Premier Producer Of Molybdenum

Ore reserves huge—A unique system of mining—Detachable bits now standard—Flotation used in concentrator—Operating basis is 4,000 tons per day

W. J. Coulter
General Manager
Climax Molybdenum Company
Climax, Colo.

ON THE BACKBONE of the Rocky Mountains, at 11,400 ft. elevation, at the top of Fremont Pass, is the plant of the Climax Molybdenum Company, 12 miles north of Leadville. The property is the largest present producer of molybdenum and has ore reserves in excess of 100,000,000 tons, with the known mineralized area only partly explored. Climax geology is covered in detail in United States Geological Survey Bulletin No. 846-C. Operations are being conducted on a 4,000-ton per day basis. The product shipped is molybdenite concentrate averaging 90 per cent.

Mining is done by a caving system unique in its application to this orebody. The method is a modification of both the Miami and Alaska Juneau practices. The orebody is undercut horizontally, with rooms and pillars on the mining level, which is 100 ft. above the haulage level. Powder tees driven from coyote drifts are spaced at intervals of 30 ft. vertically and horizontally in the area above the mining level.

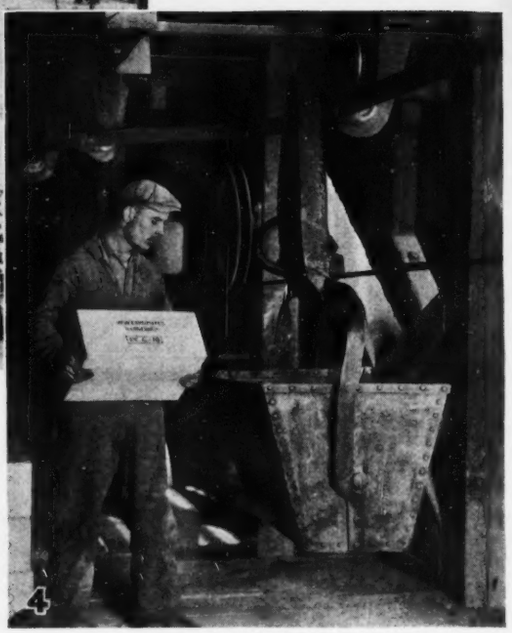
In blasting, delayed electric caps are used, the horizontal pillars on the mining level are first to be fired, and the powder tees spaced at vertical intervals of 30 ft. above are detonated in sequence. Inclined undercuts along the hanging wall or outer zone of the orebody and along the footwall near the silicified core, similar to the horizontal undercuts on the mining level, are carried up at the limits of the area to be caved. The haulage drifts are 9 ft. high by 12 ft. wide, and chutes are spaced at intervals of 100 ft. on each side. The raises branch out from each chute and go up to grizzlies spaced at 50-ft. centers on the grizzly level 60 ft. above. From each end of a grizzly a raise is put up to the mining level 40 ft. above the grizzly level. These raises are belled a short distance above the grizzlies and the horizontal pillars already referred to on the mining level are left in the center between four grizzly raises. These pillars are well drilled and the first to be blasted when an area is shot.

Grizzly chambers are 24 ft. long, 12 ft. wide, and 7 ft. high. Special crane rail sections weighing 340 lb. to the yard are spaced for 3-ft. openings. The rails are 12 ft. long and supported at the center by a specially designed reinforced steel beam. Chutes are 6 ft. wide at the cap and 4 ft. at the lip, and the flow of ore through them is controlled by air-lift finger gates.

The ore is loaded into 10-ton Granby-type side-dump cars, twenty of which make up a train. A 20-ton trolley locomotive handles the train, the average length of haul to the ore bins being a mile. Both cars and locomotives are equipped with Westinghouse air brakes and Timken roller bearings. Forged wheels are used on the cars. The track is 36-in. gage and the rail 60-lb.

Ore from the mine is delivered to a 500-ton concrete ore bin at the crushing plant, where it is fed to a 48x60-in. Buchanan steel crusher by a Ross feeder. The crusher reduces the ore to 12 in., and a 7-ft. standard Symons cone crusher then further reduces it to 2 in. The finished crushing is done by two 7-ft. Symons short-head cone crushers. These are in closed circuit with Traylor vibrating screens, the openings in which are ½x¾ in. The final product going to the mill is all minus ⅜ in. The crushing plant has a capacity of 6,000 tons per day.

Climax's mill consists of two units, No. 1 and No. 2. The rated daily capacity of No. 1 is 2,800 tons, and of No. 2, 1,200 tons. In the No. 1 unit the feed from a 1,500-ton storage bin is conveyed by belts to three 6x6-ft. Allis-Chalmers mills for primary grinding. The discharge from these is elevated to one 78-in. submerged Akins classifier and two 8x24-ft. Dorr classi-



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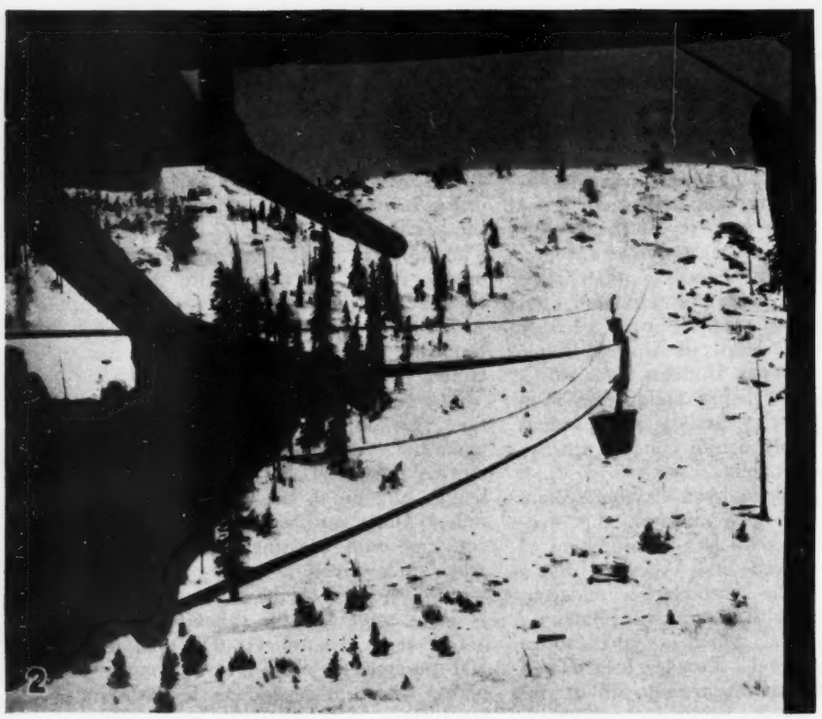

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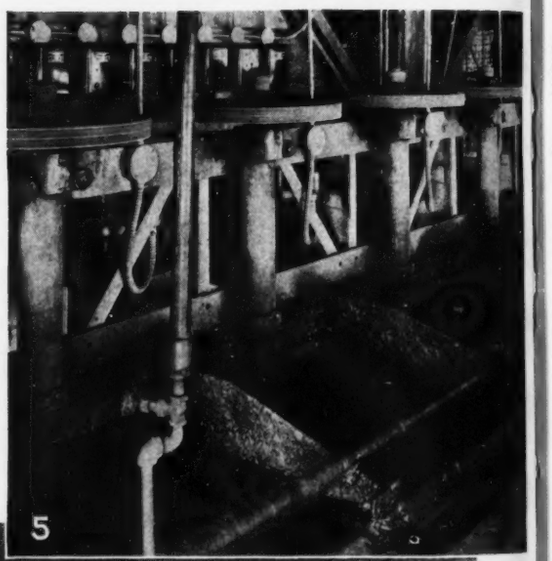


5

MINING on the CONTINENTAL DIVIDE

1 PLANT of London Butte Mining Company, at Alma. Most mines in this district are 11,500 ft. above the sea

2 UPPER terminal of Fairplay Gold Mines' 3,300-ft. aerial tramway at Alma. This carries ore from mine to mill

3 LONDON Gold Mines Company, on London Mountain between Alma and Leadville, is an old-time producer

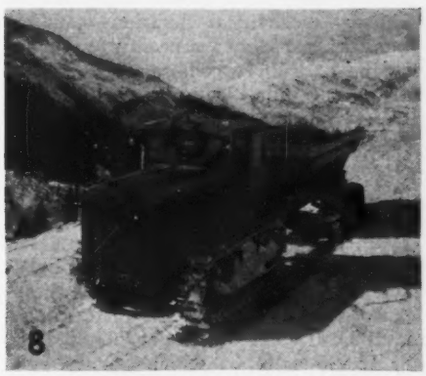
4 LOADING dynamite into a tramway bucket at the Fairplay Gold Mines' mill for the mine

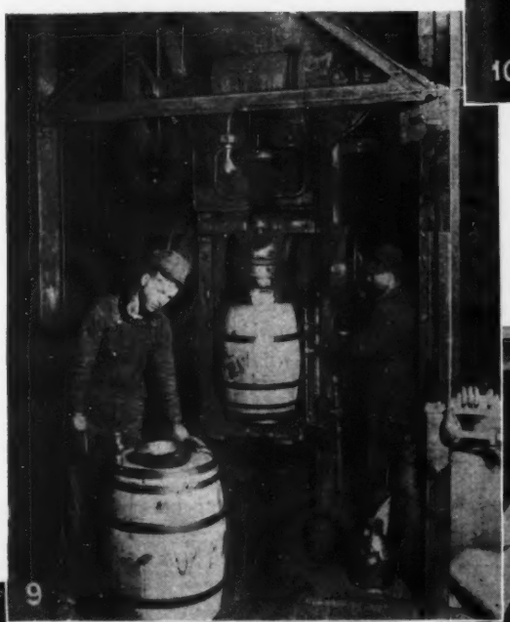
5 BATTERY of ten Hebbard-type flotation cells in mill of London Gold Mines, at Alma

6 THE PLANT of Climax Molybdenum Company, at Climax, 12 miles north of Leadville and 11,400 ft. above the sea

8 HAULING ore near Alma. Despite the climate, operations are maintained all year

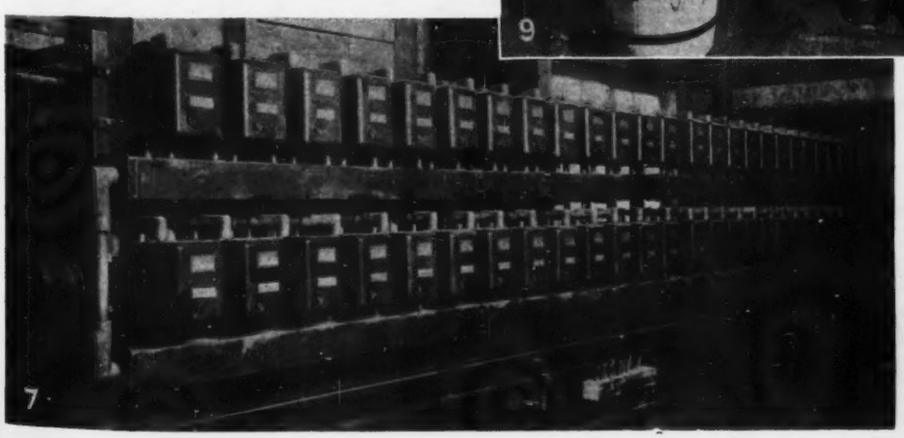
9 LOADING molybdenum concentrates for shipment at the Climax plant





10 THIS PUMP is lifting water from a shaft, sunk by Climax Molybdenum Company primarily for mill supply

11 A SPIRAL CLASSIFIER in the Climax mill. This is the largest of its type yet built



7 SWITCH control panel in the flotation section of the Climax Molybdenum

fiers. The sands from the latter are reground in two 6x10-ft. Allis-Chalmers mills, the discharge of which is returned to the classifiers by elevators. Density in the classifiers is maintained at around 42 per cent solids, the screen analysis of this overflow approximating 45 per cent plus 100 mesh. The classifier overflow passes to four banks of Type B Climax mechanical flotation machines of twelve cells each. A rougher concentrate is made in the first three cells of each of these machines, and the concentrate from the last nine cells is returned to the head. Tailings from the last cell go to the tailings pond.

The rougher concentrate assays approximately 45 per cent MoS_2 and passes to a rougher cleaner, where its grade is raised to around 53 per cent MoS_2. Concentrates from the rougher cleaner pass to an 8x24-ft. Dorr Multizone classifier, the overflow of which is adjusted to give a minus-200-mesh product, the sands going in closed circuit to a 5x20-ft. pebble mill. Overflow from the classifier mentioned then goes to an eight-cell Climax flotation machine for final cleaning. The concentrate is given four stages of cleaning in this machine, the final product assaying approximately 90 per cent MoS_2. Finished concentrate from the cleaner then flows by gravity to the drying and packing plant, where the percentage of solids is raised from 15 to 50 per cent in a 20-ft. Butchart thickener. The pulp from the thickener is pumped by a 4-in. diaphragm pump to a 5x8-ft. Oliver filter, which reduces the moisture in the concentrate to 18 per cent. The concentrate from the filter passes over a Lowden dryer, which further reduces the moisture to 3 to 4 per cent. From the Lowden dryer a No. 6 Redler conveyor discharges the concentrates into a 25-ton steel bin. At the bottom of the bin the finished product is drawn off through an Allis-Chalmers packing machine and packed in either sacks or barrels. The concentrate is packed in heavy paper-lined jute sacks for domestic shipment to Langeloth, Pa., and in first-quality oak barrels for foreign shipment.

In the No. 2 mill the feed is conveyed from a 1,500-ton steel bin by a 30-in. pan conveyor to a 9x8-ft. Marcy mill. This grinding unit is in closed circuit with a 78-in. duplex submerged-type Akins classifier, and no auxiliary lifting device is used to put the ball-mill discharge into the classifier. High circulating loads, 7 to 1, are carried in the classifier and ball mill. The classifier overflow is pumped to three ten-cell Climax mechanical flotation machines in which a rougher concentrate is made in the first three cells, as described in the No. 1 unit. This rougher concentrate from the three machines is then raised in grade in a four-cell rougher cleaner, and the concentrate from this machine is pumped to the No. 1 unit, where it enters the circuit in the Multizone classifier.

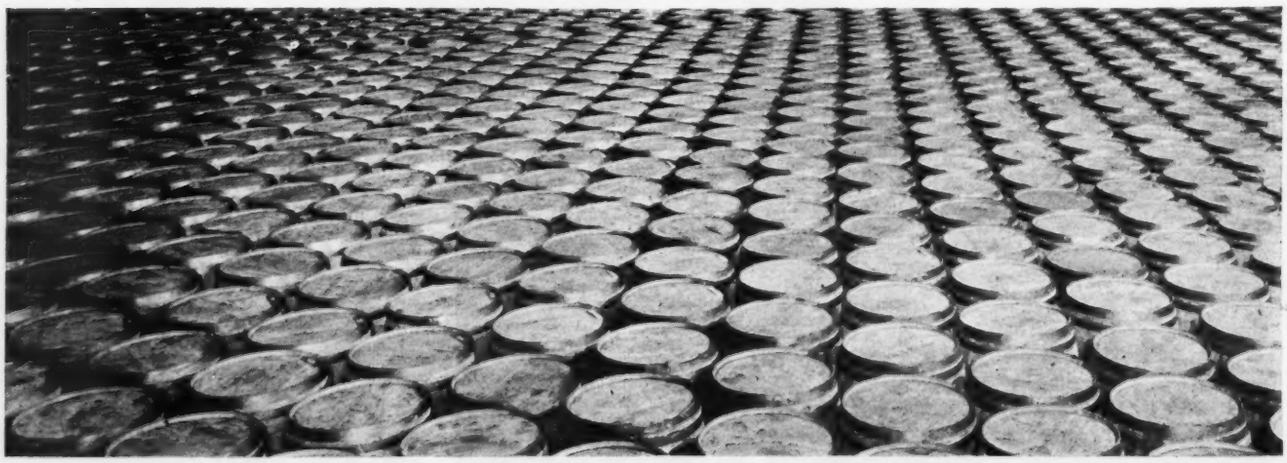
Power is supplied to the Climax company by the Public Service Company of Colorado, which brings it in at 100,000 volts and transforms it down to 13,800 volts, at which voltage it is delivered. Climax transforms it further at centralized points to 440 volts, in which form most of the power is used. For lighting, 110-volt current is used; in a few scattered applications, 220-volt.

A 5,000-cu.ft. Ingersoll-Rand compressor is centrally located in the core of the orebody on the Phillipson level in a room 40 ft. wide by 90 ft. long and 14 ft. high. Two 800-ft. compressors and a 200-kva. motor-generator set for motor haulage are also installed in this station. The big compressor is driven by an 800-hp. 440-volt synchronous 60-cycle 3-phase General Electric motor. Power is brought in at 13,800 volts in a submarine cable and transformed to 440 volts in a room adjoining the compressor station. Two air receivers with a total capacity of 6,500 cu.ft. are installed in a room adjoining the compressor station on the end opposite the transformer rooms.

Timken detachable bits are used underground exclusively on all types of machines, which include jackhammers, stopers, and drifters. They are successfully used in hard ground on such large drifting machines as the Gardner-Denver D99 rock drills, and have proved satisfactory. It has been found that detachable bits have many advantages in their application at Climax, the outstanding of which is the solution of a bad nipping problem, and it has been proved that the per bit cost is approximately half of that for standard mine steel. Between 50 and 60 machine shifts daily are now using these bits.

The Timken bits were selected after testing several other types. They are said to give more footage than ordinary forged steel. Preliminary comparative cost figures for the two are $0.124 per run for the detachable bits and $0.205 per run for forged steel. The principal items in the cost per run for the detachable bits were $0.048 for new bits, $0.021 for grinding labor, $0.014 for grinding wheels, and $0.012 for steel consumption. Tempering bits cost $0.005; forging shanks and threads, $0.006; repairing and straightening, $0.002; sorting and testing bits, $0.007; nipping shanks, $0.004; checking bits in and out, $0.002; and grinder upkeep, $0.003. The costs given for the detachable bits are thought to be slightly high and those for the forged steel to be conservative. One of the detachable bits averages about six runs. The ground drilled varies from soft and broken, where a single set of bits will drill six to eight holes, up to hard, where two sets of bits are required for one hole.

A MILLION DOLLARS' WORTH of molybdenum concentrate, barreled for shipment abroad, in plant of Climax Molybdenum Company



Alma's Output Chiefly Gold ... Both Lode and Placer

Narrow veins worked selectively—Relatively, much development required—Small blocked-out reserves—Local ores amenable to flotation

H. L. Tedrow

General Superintendent
London Gold Mines Company
Alma, Colo.

THE ALMA DISTRICT is about 100 miles southwest of Denver on the east side of the continental divide. It is served by the Colorado & Southern Railroad. In general, it is accessible throughout the year. With few exceptions the mines are at or above an elevation of 11,500 ft. above the sea. Despite the winter climate, all-year operations are maintained. The Arkansas Valley smelter, at Leadville, and the Golden Cycle mill, at Colorado Springs, provide an outlet for the crude ore and concentrates of the district. Transportation of supplies and shipping products is accomplished either by rail and truck or by the latter alone. Power is supplied by the Public Service Company. Timber is abundant.

Besides the lode mines, placers yield considerable gold. Several large areas are being tested for dredging. Although the local ores carry silver, lead, copper, and zinc, the greater value is in the gold, and the district is considered essentially a gold producer. This is one of the oldest districts in Colorado, and, like others, has passed through periods of intensive production and relative stagnation. Better metallurgical treatment, improved transportation and power facilities, a better understanding of the geology, and the increased price of gold, have each contributed to the success of operations in recent years.

The typical ore is a sulphide occurring in rather narrow veins in porphyry intrusions and irregular bodies in sedimentaries. High-grade ore occurs in places, and the usual practice, even with milling facilities, is to ship it separately. The largest mill has 150 tons' capacity. Much sorting is done in stopes and on the surface, and attention is given to reducing dilution.

Though some development is being done on the irregular deposits in the sedimentaries, present operations are almost wholly confined to the narrow higher-grade veins in the porphyries. Due to the narrow widths of the veins (6 in. at times), and to the prevalence of faulting, much development work is required. Even with milling facilities, ratios of 4 tons of ore per foot of development work required are not uncommon and lower ratios must be expected where only shipping ore is mined. The lighter diamond drills, with a capacity of 300 to 400 ft. of hole, are used in connection with underground development.

Because of conditions, shrinkage stoping is not widely practiced. The usual stopes are a form of fill stoping, and, wherever necessary, the ore is stripped and shot separately. Waste is sorted out in stopes for fill, and additional fill is obtained from the walls. Stulls are used for support, where necessary, until the stope is filled. Mucking is done by hand because of sorting, and chutes are spaced on 25-ft. centers.

Wet drills are commonly used. In narrow stopes, automatically rotated stopers have an advantage. Detachable bits are favored, particularly where the distribution of drill steel is a problem. Transport in the larger properties is effected by storage-battery locomotives in trains of 10 to 30 tons' capacity.

No large blocked-out reserves are maintained. Mining practice, in brief, is adapted to the selective working of narrow veins requiring a comparatively large amount of development. Conditions do not favor low per-ton costs.

Flotation preceded by tabling was successfully introduced in 1932, until which year production was largely from direct shipping ore. In general, the local ores are amenable to this treatment. Concentrates are shipped. Though some test work is under way to determine the possibilities of cyanidation of the tailing and locally treating the concentrates to produce bullion, nothing definite has been done.

Surface sorting is accomplished at one plant by washing the mine ore in a screen with ¾- to 1-in. openings and passing the oversize on a belt conveyor before the pickers. The screen undersize goes to a dewatering drag classifier, the solids joining the picked ore and the overflow going to the mill, where, after thickening, it joins the circuit. From 15 to 20 per cent of the mine ore is discarded as waste.

Ball mills, fed by automatic feeders, are used for fine grinding. Generally, 4-in. and 3½-in. cast balls are used. The ball mill is usually equipped with a Weinig spiral screen on the discharge end. Undersize is treated in a unit cell flotation machine and on Wilfley tables, or on the latter alone. The principle at this stage is to recover as much of the coarse free mineral and free gold as soon as possible, not only to increase the recovery, but also to reduce the amount of sulphides to be ground. The tailings of this circuit join the oversize from the spiral screen and go to a Dorr classifier. Circulating loads of from 300 to 700 per cent are usual in the latter circuit. Some hydraulic classification is done before tabling, and generally a small, high-grade cut is taken off at the top of the table concentrate. This is sacked and shipped separately. Use of blankets, traps, riffles, or amalgamation is not common.

Classifier overflow constitutes the flotation feed, which is not generally conditioned. Various types of flotation machines, including the Hebbard and Denver Sub A, are used, with the usual system of recleaning a rougher concentrate. The flotation tailings go to a Wilfley table. A coarse cut is taken from this, which joins the froth from the scavenger cells of the flotation machine and, after being dewatered in a drag classifier, returns to the ball mill. Although some classification is obtained in the drag classifier, its main effect is to dewater to permit close control of the ball-mill and classifier densities.

The flotation concentrate is thickened and filtered with the concentrate from the table in the ball mill-classifier circuit. This mixture of the two provides an excellent product for filtering.

Pine oil and xanthate are the common reagents. Fuel oil is used to depress the shale present in all veins.

The ratio of concentration varies from 6 to 12 tons into 1, and 90 per cent extraction should be obtained.

Tailings are sent to settling ponds, where the solids are settled out, to avoid pollution of the streams.

In recent years the most successful operations have been those along the west flank of the London Fault—the predominating geological feature of the district. Lower geological formations elsewhere in the district have had impressive production in the past. These are now receiving attention, with indications that large-scale, low-grade operations are possibilities.

THE FRONT RANGE—

Boulder, Gilpin, and Clear Creek Counties

▼▼▼

Many Shippers in Boulder County . . . St. Joe the Largest

Production includes gold, silver, tungsten, fluorspar, copper, and lead . . . Numerous prospects brighten outlook . . . Flotation facilitates milling, but problems remain . . . Experience with telluride ores informative

C. O. Larson

Metallurgist and Chief Chemist
St. Joe Mining & Milling Company,
Boulder, Colo.

BOULDER COUNTY, in the north central part of Colorado, has a surface ranging from rolling plains to the rugged continental divide. The mountainous portion produces gold, silver, tungsten, fluorspar, copper, and lead. History credits the county with the first discovery of tellurides made on the continent.

Late in 1858 a group of prospectors followed the main ridge between Left Hand and Fourmile canyons and camped near the present townsite of Gold Hill, where they found gold in a gulch called Gold Run. The next spring the lodes were located. The gold was recovered in sluice boxes and arrastres. Stamp mills were erected in Left Hand Canyon and ran until the oxidized ores were exhausted. In 1872 the operators of the Red Cloud mine discovered an ore which assayed high in gold, but which when treated in a stamp mill yielded none. The ore was finally recognized as gold telluride.

As with the tellurides, the silver ore at first failed of recognition. The first property was located in 1869. Only a few silver mines have been worked in recent years, but with the increased price of silver others will start producing.

Tungsten, likewise, when first found by S. P. Congor, was not identified at once. After its recognition, the discoverer secured a lease on a property, which is now the Congor mine. This find led to the opening of the largest known deposit of ferberite in the world. Fluorspar deposits were worked in the early 'seventies. Copper and lead as thus far mined have been simply by-products.

Of the mines recorded as producing in 1934, approximately 120 yielded less than a half a ton of ore and virtually were prospects. The shippers for the most part were lessees without finances, and they often abandoned good prospects. Production figures for Boulder County show the greatest percentage increase for 1934 over 1933, in the production of gold and silver, of any county in the State. Very little outside capital was in evidence until the latter part of 1933 with one exception: the St. Joe Mining & Milling Company, which started operations in October, 1932, and now employs nearly a hundred men. Up to June, 1934, this company, through A. A. Zangara, resident manager, spent several hundred thousand dollars in development work before returns began. Besides rehabilitating the mines, the Boulder Ore Sampler was purchased and opened on June 1, 1933. This was done so that the small shippers would have a place to market their ore, ranging in lots of a few pounds to several tons.

Due to the increased tonnage in 1934, the Colorado Southern and the Union Pacific railways were forced to construct additional loading ramps and to assign cars to ore service between Boulder and Colorado Springs or Leadville. At present twenty cars of ore can be loaded simultaneously at the ramps. Even then the shippers are forced to wait a day or two because of lack of facilities. The railroads spent thousands of dollars during 1934 to take care of the increased business. This outlet seems justified, as 332 cars of ore left Boulder during the first five months of 1935 for Colorado Springs or Leadville. In addition, several shippers truck their higher grades of ore and concentrates to the Golden Cycle plant, at Colorado Springs.

Tungsten mining also experienced a revival in 1934 after a period of several years during which shipments were made at intervals from stock. Four carloads of ore were shipped east to the steel companies in the first five months of 1935. The Tungsten Production Company and the Wolf Tongue Mining Company purchase ore and mill it in their plants at Tungsten and Nederland.

For the most part, the mines employ the cut-and-fill method. To some extent, open-cut and glory-hole mining are used. The Grand Republic mine, owned and operated by the St. Joe Mining & Milling Company, is the largest producer in the county. The oreshoot averages 30 ft. in width and 400 ft. in length. Owing to its size, a glory-hole method is used. Timbering is too costly, so pillars of ore are left for supports. The mine is fast becoming one of the largest in the State, development being done simultaneously with the mining. To date three levels have been worked, and the deposit on each succeeding level is larger than the one above it. A three-compartment shaft has been sunk 100 ft. with two levels 50 ft. apart and a crosscut on each to the orebody. On the present basis each level will produce sufficient ore to keep the mill running for a year. The mine is electrically equipped, the power being supplied by the Public Service of Colorado.

None of the mines of the county have attained any great depth. The deepest gold mine is the Slide, operated by the Slide Mines, Inc. It has a depth of 1,000 ft. The Congor, which produces

...Scene of Earliest Finds

Show Increasing Activity

tungsten, has attained a depth of 1,160 ft.

Milling methods have gone through all stages of experimentation: stamp mills, smelters, concentrators, and chloridizing and cyanide plants. None proved successful, and recovery in some cases was estimated as low as 25 per cent. With the advent of modern flotation, milling in the county entered a new phase. At present, the proper treatment of the ores is only partly worked out: the values can be concentrated into a small bulk. The concentrates are then shipped to either the Golden Cycle or to the American Smelting & Refining Company for reduction into bullion.

The largest, most modern, and best-equipped mill is that of the St. Joe company. The ore is hauled 7 miles from the Grand Republic and St. Joe mines in the company's trucks. Owing to the research it has conducted, the company is now able to treat its refractory sulpho-telluride ore successfully by flotation.

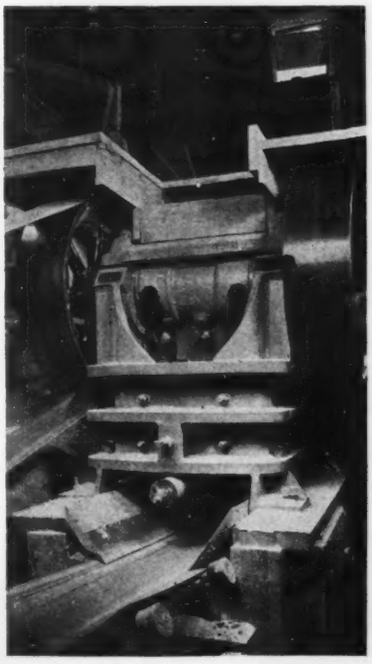
Mine-run ore is crushed to minus ¾ in. in a Telsmith 13x24-in. jaw crusher, sampled by a double Snyder sampler, and sent to the fine-ore bins. From these an apron feeder delivers it onto a conveyor, which discharges it to a 5x9-ft. ball mill. This is in closed circuit with two Wilfley tables, a No. 500 Fahrenwald unit cell, and a 6-ft. Dorr classifier. Overflow of the latter goes to a conditioner and then to an eight-cell unit of a Fahrenwald machine. The concentrates from the latter and the unit cell are combined and dewatered by dragline and shipped for re-treatment.

Considerable experience has been had with tellurides at the St. Joe mill. With the increased price of gold, tailing losses that were thought reasonable soon became prohibitive at the time when the plant was operating on custom ores before the production of the Grand Republic mine was sufficient to supply its needs. During that period the mill heads consisted of a mixture of sulphide and telluride ores. Much research work was done, using a sulphide ore, a sulpho-telluride ore, and a telluride ore. Recoveries were always in this order. This led me to believe that the excessive losses were caused by the tellurides, and I attacked the problem from that angle. In studying the results that obtained in this test work two points stood out: (1) The effect of sliming or excessive grinding; (2) the effect of activation upon recovery.

Tailing samples from a sulphide ore and a telluride ore were screened and the various screen sizes assayed. Both ores have been ground to 50 per cent minus-300 mesh. Assays of the screen sizes of the sulphide tailings were in a descending order, with a very slight rise in the minus-300 product. On the other hand, the assays of the screen sizes of the telluride tailings were in a descending order down to the minus-200/300 bracket, then rose sharply so that the minus-300 product was as high in value as the 80 product.

The mill then used stamps for a primary grind, followed by a ball mill in closed circuit with a Dorr classifier. Inasmuch as we had no laboratory classification equipment, we were forced to do our testing in the mill proper. We replaced the 10-mesh screens on the stamps with fours and sixes. The classifier overflow was maintained at the same percentage of solids, and we obtained about the same final grind as far as the screen analysis could show, but the mill recovery was vastly improved. The assays of the screen sizes showed a marked improvement in the finer sizes. Further mill test work was conducted, and the only conclusion that could be arrived at was that in milling

PRIMARY JAW CRUSHER, 13 by 24 in., in plant of St. Joe Mining & Milling Company, at Boulder



telluride ores the grinding and classification circuit must be closely controlled, as the uniformity of grind plays a more important part in the subsequent flotation process when tellurides are being milled than when sulphides are being milled.

The activation of the tellurides by the use of copper sulphate had improved recovery approximately 10 per cent over and above that obtained without an activator. Other known activators did not seem to improve recovery beyond that point. I decided to try a lead salt as the activator, lead ores being more amenable to flotation than copper ores. For the most part lead salts are not very soluble, and I was limited to those that could be used. Lead nitrate, lead chloride, and lead acetate were tried. Of these, the nitrate alone proved valuable, regardless of the fact that nitrates have in the past been used as depressants and are considered as such.

Comparative tests on a telluride ore were made as follows: No activator, copper sulphate as the activator, and lead nitrate as the activator. The results were in round figures as follows: (1) No activator, 70 per cent recovery; (2) copper sulphate, 80 per cent; (3) lead nitrate, 90 per cent. Check tests were then made. The recovery was improved in all cases by the use of lead nitrate, but the increase was lower on the sulphide ores and sulpho-telluride ores. A mill test of 40 hours was then made, substituting lead nitrate for the copper sulphate, and the recovery was increased 13 per cent over that of the preceding shifts.

During July and August, 1934, the mill heads assayed 0.23 oz. per ton and the tailings 0.023 oz. per ton. The mill recovery was slightly over 90 per cent with a ratio of concentration of 20 to 1. During this period, two of our shipments of lead nitrate were delayed and we returned to the use of copper sulphate. Both times the recovery dropped below 80 per cent, but as soon as the lead nitrate was reintroduced the recovery immediately increased to 90 per cent or better.

The Slide Mines, Inc., operate a mill a short distance below the St. Joe plant and have the only Hadsel mill installed in the State of Colorado. They also float their sulphide ore, produced from the Slide mine. Several other mills are operating spasmodically. Still other operators are considering the erection of plants during the present year.

ON THE FRONT RANGE

1 WOODMOUNTAIN mine of Tungsten Production Company, near Ward, in Boulder County. Here a gold-silver ore is reported to be milled

2 PLANT of Slide Mines, Inc., in Boulder County. Among other equipment it houses a Hadsel mill. Underground workings reach a depth of 100 ft.

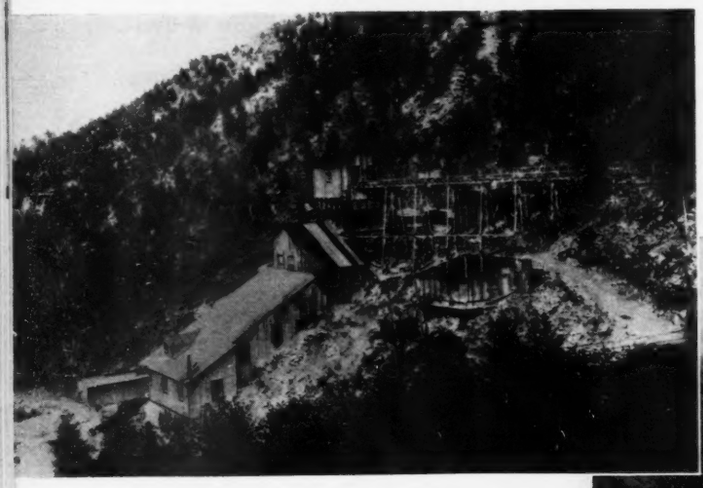
3 ALMA LINCOLN Mining Company's property at Idaho Springs, in Clear Creek County. A tramway 1,172 ft. long connects the upper level with the mill bins near the portal of the main adit

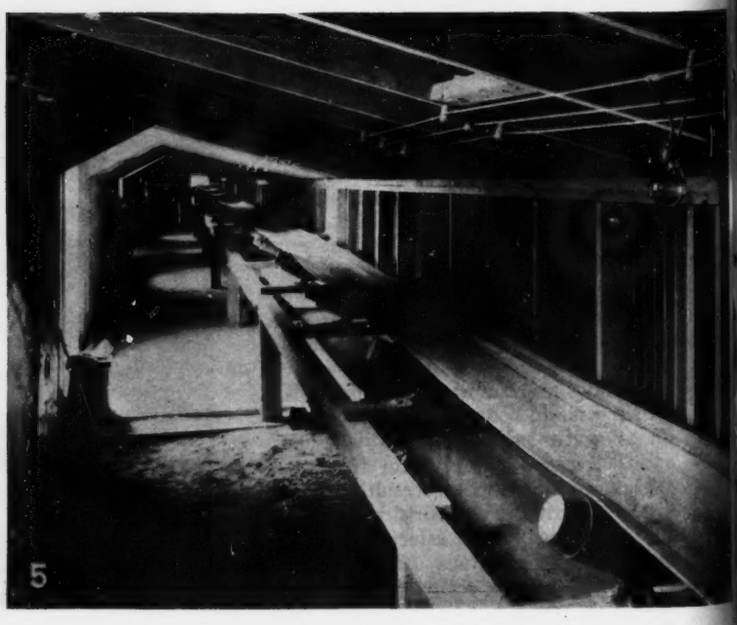
4 CONCENTRATOR and surface plant of the St. Joe Mining & Milling Company, at Boulder. The largest mill in the county. The company employs 100 men

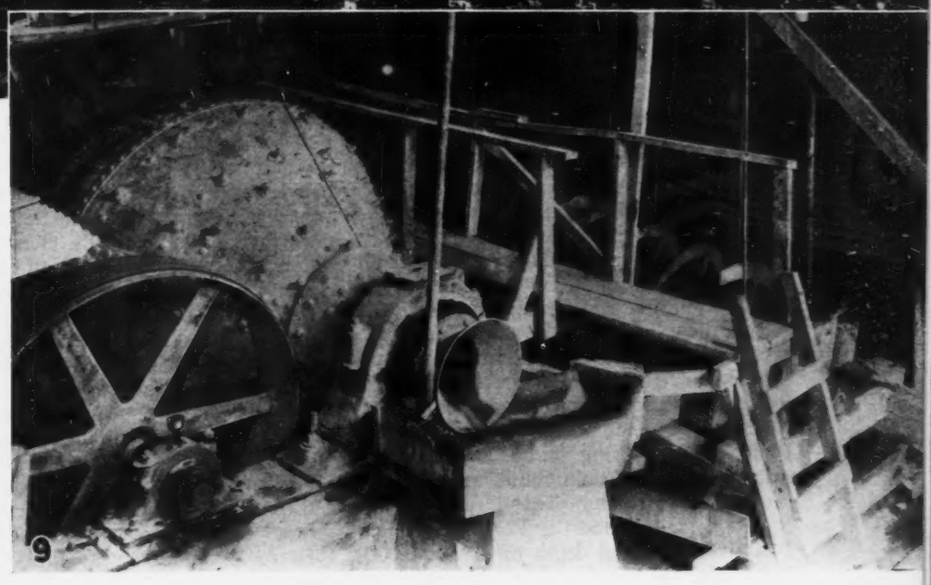
5 THIS 115-ft. belt conveyor handles ore between the primary and the secondary crushers in the St. Joe concentrator

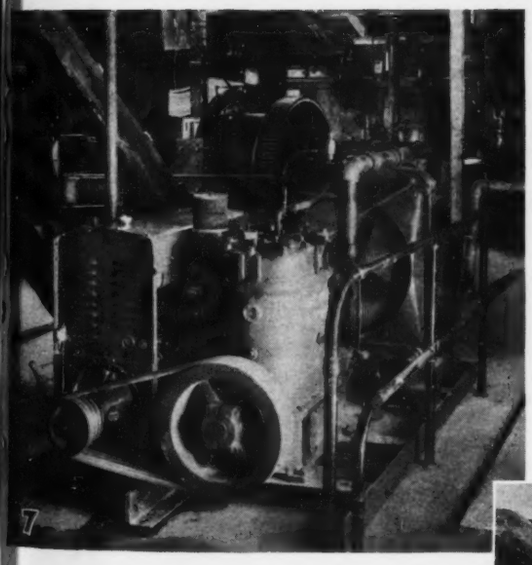
6 DENVER, mining and financial center of Colorado and gateway to the Front Range, as it appears from the air

7 HOIST and compressor room of the Eureka mine at Central City. The diesel-driven compressor supplies air for two jackhammers. A larger compressor is not shown









8 PORTAL of the 5-mile Argo tunnel, at Idaho Springs. The trolley locomotive is hauling a trip of 3-ton cars

9 IN THE MILL of the Clear Creek & Gilpin Ore Company at Idaho Springs. Ball mill, classifier and thickener

10 PITTSBURGH MILL, operated by the Russell Gulch Mining Company, at Central City. Its capacity is 260 tons per day.

Eight Mills in Clear Creek And Gilpin Counties

Three of them custom plants and a sampler besides . . . All are running . . . Local ore treatment simple; improvement awaited . . . Flotation in use . . . Cyanidation alone to be tried

A. W. Newberry

Mining Engineer,
911 Equitable Building,
Denver, Colo.

PRELIMINARY FIGURES show a production of 18,115 oz. of gold, 122,354 oz. silver, 149,000 lb. of copper, and 715,000 lb. of lead for Clear Creek and Gilpin counties in 1934. One custom sampler and eight mills, all of them concentrators, are in fairly continuous operation. Three of the eight are custom plants. Concentrate goes either to the American Smelting & Refining Company's smelter, at Leadville, or to the Golden Cycle cyanide plant, at Colorado Springs. One cyanide plant is under erection.

In addition to the mines that have their own mills, a few ship crude ore. Other properties are still in the exploration stage. By far the greater part of this work is in old mines at depths of 400 to 1,000 ft. The deepest man-made opening in the two counties is in the California mine, at 2,250 ft. on a 79½-deg. dip. The deepest accessible opening is the Big Five adit, which attains a vertical depth of almost 2,000 ft.; and the deepest accessible point at which productive veins have been cut would be about 1,800 ft. from surface in workings tributary to the Argo tunnel.

The region is one of narrow, steeply dipping veins, and frequent oreshoots, many of which pitch at angles of less than 45 deg. Most of the shoots that remain are short and narrow and generally require great skill for profitable extraction. Shrinkage stoping can be used successfully in most cases, provided the stope is worked out rapidly and care is used in supporting the walls. Where the dip is under 60 deg. or the wall rock tends to slab, some other method is necessary. Resuing was widely employed 40 years ago where shrinkage stoping proved impracticable. This is now used principally where lessees are working and are inclined to break waste and ore cleanly.

The long adits driven from Clear Creek should make a large tonnage of new ore easily accessible. Exploration almost ceased, apparently, when they were driven and is only now getting under way again.

Local ore treatment is comparatively simple. Because of the high pyrite content of most ores and the favorable smelting rates on material high in iron and sulphur, little metallurgical refinement has been achieved. Probably, in most cases, gold favors the ores relatively high in chalcopyrite, and silver those in which galena or galena and blende predominate. The principal silver carrier in ores of the latter type, nevertheless, is probably tetrahedrite. Attempts at selective flotation in which these copper, lead, and zinc minerals are separated from the ever-present pyrite have been reasonably successful from a technical point of view, but the problem remains of disposing of the secondary pyrite concentrates, assaying a fifth to a third of an ounce in gold and one to four ounces in silver. Inasmuch as such material will usually pay freight and treatment, the common practice is to ship all concentrate—amounting to from 1/50 to ¼ of the ore treated—to the smelter.

Wilfley and Bribach, in testing ore from the Alice mine, have succeeded on a laboratory scale in eliminating a pyritic product that is too low grade to ship. An important field for research offers itself in the treatment of this low-grade product at the point where made.

Another opportunity for research is in the treatment of concentrates which can be made by selective flotation at those mines where the ore contains much blende. Most mines of this class are now idle, but further increase in the price of silver may cause some to be reopened. The nearest market for zinc concentrate is Amarillo, Tex. Smelting rates are $18 to $21 per ton, and only 80 per cent of the zinc and 65 per cent of the gold, silver, copper, and lead are paid for. In addition, a charge of $5 per ton is made for the marketing of residues. This situation should provide a real incentive for local recovery of the precious metals from a zinc concentrate where the zinc content is over 8 per cent, or sufficient to incur a penalty.

In the Fall River area, in Clear Creek County, work started the past April at the Alice, near the head of Fall River, 9 miles northwest of Idaho Springs. Here, in the early days, the oxidized zone was hydraulicked, yielding 3,000 oz. of gold from an area 200x 500 ft. Beneath this mantle of oxidized ore, development had disclosed a stockwork roughly 250x300 ft. in plan, a substantial part (though probably considerably less than half) of which assays 0.22 oz. gold and 1.2 oz. silver.[1] Ground has been broken for a 35-ton pilot mill. Tests indicate that 30 to 50 per cent of the gold will be saved by amalgamation. Equipment is to consist of a crusher, a ball mill, a Clark-Todd amalgamator, flotation cells, and a pilot table.

Two miles west of Idaho Springs on the south bank of Clear Creek is the Alma Lincoln mine. Access is by adit driven southward 765 ft. along the E. & B. vein. At this point a crosscut is run westward, cutting three more veins at depths of 400 to 600 ft. Average vein width is 4 ft. The E. & B., dipping 65 deg. west, is the only vein steep enough for shrinkage stoping. The Lincoln vein, the most westerly, has the flattest dip, 40 to 45 deg. west. An open stope is carried here with stulls for support.

A tramway 1,172 ft. long connects the upper levels with the mill bins, near the portal of the main adit. Here the coarse ore is crushed. The present mill is of 55 tons' capacity and concentrates 8 tons into 1. Ore is ground to 20 mesh in a 3x9-ft. Ruth rod mill discharging upon a Deister roughing table. Concentrates from this contain 65 per cent of all values saved. Middlings and tailings go to an eight-cell Ruth flotation unit followed by a pilot table. Concentrates are dewatered to 6.5 per cent moisture in an Allen cone. They assay 1.7 oz. gold, 5.5 oz. silver, 1 per cent copper, 2.8 per cent lead, and 1 per cent zinc, and are shipped to Leadville. A new 125-ton unit is being installed alongside the present one. It will have a 4x8-ft. Marcy rod mill and an eight-cell Fahrenwald flotation machine. Otherwise, the flowsheet will be the same as described.

Half a mile north of Chicago Creek and west of Idaho Springs is the Little Mattie mine and mill. Access to the main workings is through a turned vertical shaft 1,020 ft. deep. There are twelve levels, somewhat irregularly spaced. Access to the northeast section known as the Newton area is through an 1,800-ft. adit driven on the main vein. The latter dips about 65 deg. and

[1] P.P. 94, U. S. G. S., p. 326.

is 3 to 6 ft. wide. Shrinkage stoping is used in blocks 100 ft. long. A manway is carried every 50 ft. and chutes are spaced 15 to 20 ft. center to center. The principal ore occurrences are at or near the intersections of the main vein, which strikes northeast, with east-west cross veins.

The mill is of 50 tons' capacity. Heads assay 0.20 to 0.35 oz. gold and 6 to 14 oz. silver per ton. A jaw crusher discharges upon a belt conveyor, which permits sorting ahead of the mill bin. Ore is ground in a 4x12-ft. Ruth rod mill in closed circuit with carpets, a Wilfley pump, and an Akins classifier. Fines from the classifier, which are minus-60 mesh, go to a roughing table making a final concentrate. Rougher middlings and tailings go to an eight-cell Ruth flotation unit, the tailing from which is passed over a pilot table.

The Clear Creek-Gilpin Company operates a custom sampler and concentrator in Idaho Springs. Most of the ore is delivered by truck. It is weighed and then crushed in a Blake type machine, followed by Cornish rolls. The roll product is elevated to a trommel of 1-in. wire mesh, the oversize returning. Undersize is sampled mechanically.

In the Empire district, in Clear Creek County, the principal operation is that of the D. A. Odell Mines Company. Here 75,000 tons of pyritic ore averaging approximately 0.5 oz. gold per ton has been developed by adits, raises, and winzes. The country rock is kaolinized alongside the veins to such an extent that waste-filled stopes will have to be carried from the outset. Stoping width will be about 3½ ft.

A 100-ton cyanide plant is being built and should be running soon. It will use counter-current decantation. Tests indicate that on minus-100-mesh material in contact with the solution 48 hours, gold recoveries up to 96 per cent may be had with a consumption of 1.1 lb. cyanide and 10 lb. lime per ton of ore. The high lime consumption is due to the use of acid mine water. Some reduction in this item should result from the development of an outside water supply. The plant is of especial interest because it is the first to be installed in the two counties within recent years in which cyanidation alone is to be used.

Waldorf Gold, Inc., 5 miles southwest of Georgetown, is preparing to operate a 25-ton pilot mill on dump ore from the Tobin group. The dumps, as sampled, show 0.23 oz. gold, 4 oz. silver, and an appreciable amount of copper as chalcopyrite. The ore contains little lead or zinc. Equipment consists of a jaw crusher, a rod mill, and tables. Ratio of concentration will be about 5 into 1. The mill is at the portal of a 6,500-ft. adit, through which the ground is to be explored at depth. The method of mining has not yet been determined.

Three other mills are operating in Gilpin County most of the time: the Gregory-Bates and the Farr mills, at Black Hawk, and the Pittsburgh mill, in Russell Gulch. The Gregory-Bates and Farr mills are the only plants in the district using stamps for fine crushing. Both employ flotation. The Pittsburgh mill has a capacity of 260 tons daily. At present most of the ore is coming from dumps and the average gold content is about 0.10 oz. per ton. An 80 per cent recovery is made on this material, which is crushed in a ball mill to pass 14 mesh and treated on tables.

In flotation work, Aerofloat is generally used as a frother. It is fed, with a weak solution of soda ash—sometimes also with a little lime—at the head of the flotation circuit at the rate of 1 to 1½ lb. per ton of ore treated. Pyrite and blende are depressed by adding a small quantity of sodium cyanide—usually less than 0.1 lb. per ton. This is added in or near the head of the circuit unless an appreciable amount of galena is present, in which case it is added further along after the bulk of the galena has been removed as concentrate. Where a zinc product is desired, a small amount of copper sulphate solution is added still further along in the circuit, this raising the blende previously depressed. Methyl xanthate, up to ¼ lb. per ton of ore, is added at the head of the flotation circuit, primarily for the purpose of enabling the frothing agent to pick up particles of free gold.

Structure Controls Deposition Of Ore in Front Range Areas

Many mining districts in Boulder, Gilpin, and Clear Creek counties—In the first, the variety of minerals is an outstanding feature

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THE Colorado Front Range is a complex mass of Pre-Cambrian metamorphic and igneous rocks locally cut by Tertiary intrusives and is bordered by up-tilted sediments of Paleozoic, Mesozoic, and basal Eocene age. Regional studies indicate that the Laramide folding which deformed the sediments and uplifted the mountains occurred during the transition from basal Eocene to lower Eocene time.

Stocks of Eocene monzonite and quartz monzonite occur in a narrow belt trending N. 40 deg. E. across the Front Range (see Fig. 1). A marked concentration of dikes, sills, and ore deposits is found to the southeast of these stocks and constitutes the "mineral belt." The Pre-Cambrian rocks cut by the dikes and veins comprise a wide variety of complexly folded schists and gneisses intruded by many different granites. The ancient sediments making up the widespread Idaho Springs formation are chiefly quartz-biotite-sillimanite schist and injection gneiss. This formation is cut by the Pre-Cambrian igneous rocks, the principal of which are the Silver Plume granite, Pike's Peak or Rosalie granite, and Boulder Creek gneiss. Though differing in appearance, these three groups of rocks are closely related, and lead-uranium ratios indicate that the Silver Plume and Pike's Peak granite are approximately 920 million and 1,000 million years old respectively.

The ore deposits did not form until after Laramide fracturing had nearly ceased, but their distribution and localization was greatly influenced by both Pre-Cambrian and Eocene structure.

Planes of weakness such as schistosity or contacts of dissimilar rocks exercised a profound influence on Laramide fracturing. The relations of the granite masses to the mineral belt, as shown in Fig. 1, suggest that they acted as buttresses between which the incompetent schist and gneiss were fractured.

Along both borders of the Front Range, folds of northwest trend are common. As the Front Range is followed south from the Wyoming line, flexures of northwest trend, which lie *en echelon*, become more closely folded, the Pre-Cambrian-Paleozoic contact is deflected farther west, and axial faults appear. This evidence of increasing compression coincides with the appearance of the mineral belt at the eastern

mountain front in Boulder County, where persistent northwest-trending faults are especially prominent and easily followed. The mineral belt itself follows a zone of nearly horizontal shearing almost at right angles to these earlier faults. The Eocene stocks were intruded along this zone of weakness after the mountain-building forces were largely spent, and in most of them fracturing is unimportant. Intrusion of the stocks was accompanied and followed by that of porphyry dikes in the earlier fractures near by. Minor adjustments that followed the period of intrusion were nearly vertical, in contrast to the prevailingly horizontal movement along the earlier fractures. Near Boulder, however, lateral compression continued to a very late stage of the Laramide revolution, causing a wedge-shaped mass of granite to move west and open the east-trending fissures that became the tungsten veins of Boulder County.

The genetic relation of the ore deposits to the Eocene porphyries has long been established.[1] Just as there are centers of intrusive activity throughout the mineral belt, there are also distinct centers of mineralization differing slightly in age. The lead-silver ores seem closely related to the earlier quartz monzonite magma and are themselves earlier than the pyritic gold-copper ores which appear to be closely related to the more alkalic magma. The bostonite and trachyte porphyries are representative types of the alkalic magma. The gold telluride ores seem everywhere younger than the pyritic gold ores, but in a few localities have been proved definitely older than the ferberite ores of the tungsten belt. The age of the ores as indicated by the lead-uranium ratios of pitchblende from the Central City district is 60 million years.

In many of the mining districts, explosive breccia or intrusion breccia is prominent in fissures and pipes of pre-mineral age. In some of the districts these breccias are found at the surface in the zone of most intense mineralization, but in other districts vesicular andesite intrusion breccia has been found at depth in veins at or near the lower limits of commercial ore. Where the breccia does not contain volcanic rock, as at "The Patch," near Central City, and in the White Raven mine, at Ward, high-grade ores may form a matrix to the rubble-like mass of country rock. The field evidence indicates that the ores were deposited by emanations from several distinct but closly related chambers of Eocene magma.

Throughout the mineral belt the factors controlling the localization of oreshoots are almost wholly structural. The amount and direction of movement along the pre-mineral faults and the character of the country rock determined the relative permeability along the fractures, and the ore fluids followed the most permeable courses available.

Strong fault movement crushed the schist to an impervious gouge while breaking the resistant rocks into a permeable breccia. Other open spaces were localized during movement along faults.

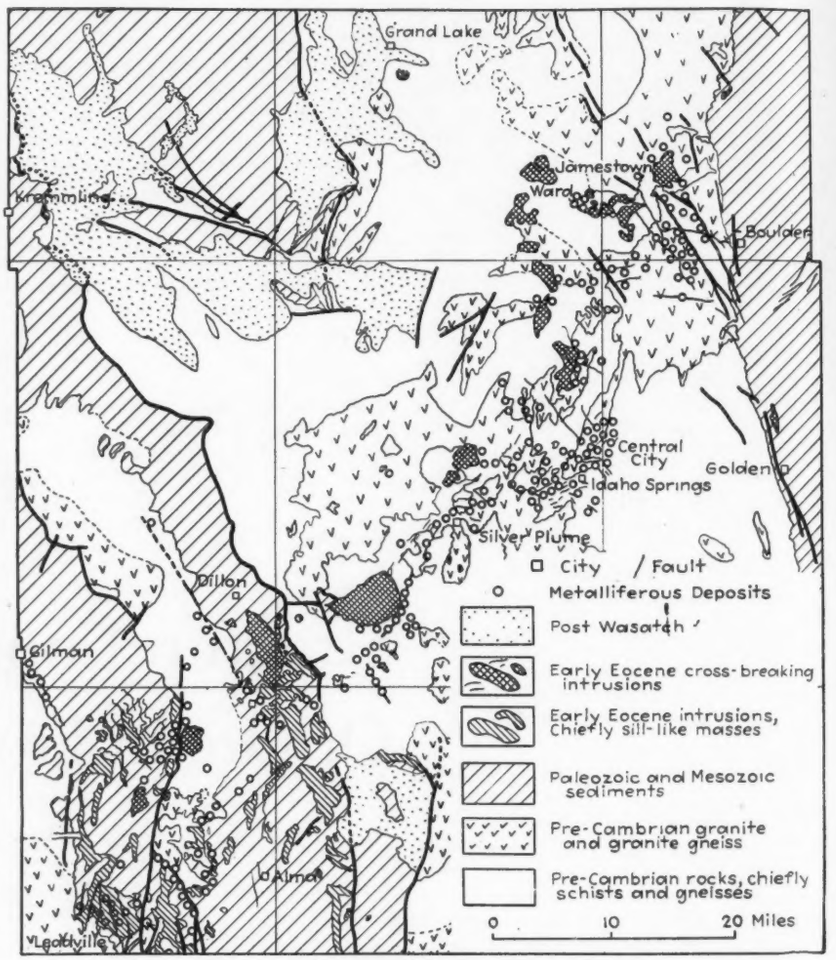
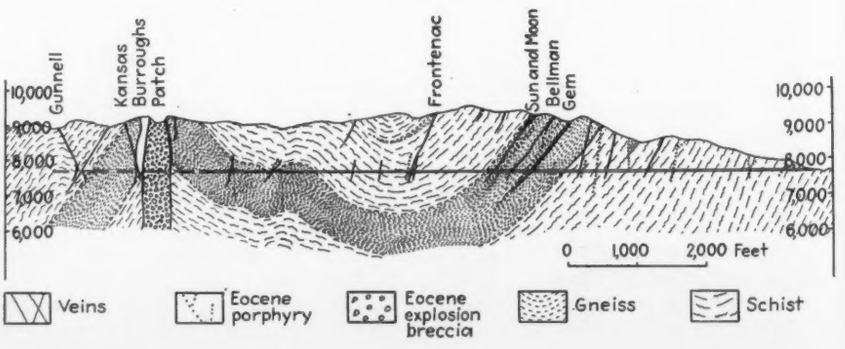


FIG. 1—THE PORPHYRY BELT of Colorado and its northern portion of mineralized areas, showing the principal mining districts

Although the altitude of the bottoms of known oreshoots suggests a gradual rise in the lower limits of workable ores from the eastern front of the range toward the continental divide[2], this apparent relation may be due to the depth of the individual outcropping oreshoots and the relative difficulty of finding blind oreshoots. It would probably be more accurate to consider the relation of the bottoms of oreshoots to the upper parts of the intrusive magma from which they arose than to depth from the present surface or their altitudes above sea level. In Boulder County there is evidence that the altitude to which the magma rose varied considerably, with a corresponding variation in the altitude at which the ores were precipitated.

The relatively inaccessible Argentine mining district straddles the continental divide in the western part of Clear Creek County, and nearly all the mining has been done above an altitude of 11,500

FIG. 2—THE ARGO TUNNEL through a north and south geologic section in the Idaho Springs and Central City mining districts. (The tunnel is 4.16 miles long)



ft. The lead-silver veins of this district are productive chiefly where they cut ribs of granite within the inclosing Idaho Springs formation. The important veins, such as the Commonwealth, Santiago, and Stevens, trend northeast toward the Silver Plume district a few miles away.[3]

Near Silver Plume the mineral belt widens out abruptly, the northern side continuing northeast through Empire and the southeastern boundary swinging nearly due east toward the Trail Creek district southwest of Idaho Springs. Most of the productive silver-lead-zinc veins of the Silver Plume district,[4] such as the Fenton, Mendota, Seven Thirty, and the Dives-Dunkirk, strike from east to northest, breaking across north-trending structures in the Pre-Cambrian rocks. The most productive vein of the district, however, the Bismarck-Pelican, follows a porphyry dike of northwest trend for more than 4,000 ft. and continues beyond it to the southeast, breaking across schist and granite. A continuous oreshoot in this vein has been followed to a vertical depth of 1,800 ft.

The rich Colorado Central silver-lead vein, a mile southwest of Georgetown, is close to the southern limit of the mineral belt. It follows a granite porphyry dike of northeast strike and has been mined to a depth of slightly more than a thousand feet.

Although the veins of the Idaho Springs and the Central City districts are in different counties, they were derived from the same source and form a natural mineral district. Schist and gneiss make up most of the country rock of this region. As in the other districts, the productive veins commonly break across the schistosity, follow dikes, or have competent wall rocks such as granite gneiss. The center of mineralization seems to have been close to "The Patch" and a rude zonal arrangement of the ores related to this general area was early recognized by Collins[5] and later discussed by Bastin and Hill.[6]

Around a central area of pyritic gold veins lies an intermediate belt of gold-silver-lead-zinc veins, bordered by a zone of silver veins. Most of the district's production has come from the veins of east-northeast trend, such as the Crown Point, Seaton, Frontenac, Druid, Mammoth, Gregory, Bates, Calhoun, California, Burroughs, Kansas, Concrete, and Gunell, but the important Gem vein, just north of Idaho Springs, has a west-northwest course and the structure of the granite gneiss parallels the vein at many places. Near the surface the pipe of explosion breccia of "The Patch" carried rich pyritic gold-copper ore, but where it was cut 1,700 ft. below by the Argo tunnel it was nearly barren.

Many mining districts occur in Clear Creek and Gilpin counties along the northern and central parts of the mineral belt, northeast of Silver Plume, and though substantial production is credited to some of the veins, they are smaller than the important veins found along the southern and eastern parts of the mineral belt of this region. In the Empire mining district, about 4 miles north of Georgetown, pyritic gold quartz veins occur in the Pre-Cambrian granite just east of a monzonite stock.

In the southwestern part of Boulder County high-grade gold telluride veins were mined at an early date. The veins near Eldora,[7] about 3 miles northwest of Rollinsville, consist of narrow seams of ore in sheeted zones from 1 ft. to 3 ft. in width, containing gold telluride, fluorite, and chalcedonic silica, and are fairly typical of the telluride veins of Boulder County.

At Caribou, 2 miles north of Eldora, an unusual composite stock occurs, comprising rocks ranging from quartz monzonite to gabbro and titaniferous iron ores. The porphyry stock itself is fractured near the eastern margin and was host to extensive silver mineralization. The rich silver oreshoot discovered on the east-trending Caribou vein lies close to the junction of the northeast trending No Name vein, into which it shifts with increasing depth. Just east of Caribou rich secondary gold ores were mined in the St. Louis and nearby veins. Farther east a silver-lead-gold ore was found in the persistent east-west Boulder County vein.

In the Ward district,[8] a few miles northeast of Caribou, the most prominent veins, such as the Columbia and White Raven, occupy remarkably persistent fissure of northwest trend and are characterized in most places by an early low-grade pyritic quartz and a later gold-copper ore. The richest ore occurs within a few hundred feet of the surface, but primary ore of profitable grade has been mined as much as 700 ft. below the surface.

The mineral deposits in the Jamestown district[9] about 7 miles northeast of Ward seem closely related to stocks of granodiorite and porphyritic quartz monzonite close to the northeast end of the mineral belt.

The discovery of new telluride orebodies in the Smuggler, Wano, John Jay, and other veins has resulted in the reopening of several mines and caused a substantial increase in the gold production.

Southeast of the zone of Tertiary stocks in Boulder County, the ore deposits show a marked relation to regional structure.[10] Many productive oreshoots occur in northeast-trending fractures near their intersections with the three persistent northwest-trending faults known as the Maxwell Dike, the Hoosier Dike, and the Livingstone Dike. In the Sugar Loaf district 6 miles due west of Boulder the productive Nyanza and Livingstone gold veins are associated with the Livingstone Dike. To the southeast it joins many gold and tungsten veins in Black Tiger Gulch and continues across Boulder Creek to the Magnolia district, noted for the variety of its rich telluride minerals. The parallel Hoosier Dike, about 2 miles northeast of the Livingstone Dike, passes through the Gold Hill, Salina, Wallstreet and Logan Hill mining areas. Gold-silver telluride oreshoots are prominent in east and northeast veins close to the "dike."

The tungsten ores of Boulder County[11] occur in a comparatively narrow belt extending east-northeast from Nederland and are chiefly in Boulder Creek gneiss and pegmatite. The southern part of the tungsten belt from Nederland to Black Tiger Gulch is marked by a persistent zone of fissuring, from which northeasterly trending branches diverge at many places. The tungsten belt terminates abruptly about a mile west of Nederland near the Congor, the deepest and most productive mine in the district. In this mine the vein was followed to a vertical depth of a thousand feet, but little ore was mined below a depth of 700 ft. The gangue of the tungsten veins is chalcedonic quartz, locally known as "horn," and is similar to the filling of the telluride veins. The tungsten ores themselves contain no gold or silver except where they cut earlier gold telluride veins, as in the Logan, Red Signe, and Kekeonga mines, in the eastern part of the tungsten belt.

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[1]Spurr, J. E., Garry, G. H., and Ball, Sidney: "Geology and Ore Deposits of the Georgetown Quadrangle." U. S. Geological Survey, Professional Paper No. 63, pp. 158-60, 1908.

[2]Lovering, T. S.: "Localization of Ore in the Schists and Gneisses of the Mineral Belt of the Front Range." Colorado Scientific Society, Proceedings, Vol. 12, pp. 242-44, 1930.

[3]Lovering, T. S.: "Geology and Ore Deposits of the Montezuma Quadrangle." U. S. Geological Survey, Professional Paper 178, pp. 109-112 (in press).

[4]Spurr, J. E., Garrey, G. H., and Ball, Sidney: *Op. cit.*

[5]Collins, G. E.: "The Relative Distribution of Gold and Silver Values in the Ores of Gilpin County." Transactions, Inst. of Min. and Met., Vol. XII, pp. 480-499, 1903.

[6]Bastin, E. S., and Hill, J. M.: "Economic Geology of Gilpin County and Adjacent Parts of Clear Creek and Boulder Counties, Colorado." U. S. Geological Survey, Professional Paper 94, pp. 133, 1917.

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Colorado Points the Way To Cooperation

W. H. TRASK, retired banker of Denver, Colo., is responsible, more than anyone else, for the cooperative geological program in the State of Colorado—the results of which from 1922 to date have made possible important contributions to this issue of *Engineering and Mining Journal*. For many years Mr. Trask, like others in Colorado, was a great admirer of the Hayden Survey, which he felt had much to do with the opening of orebodies in Colorado. From 1910 to 1921 he repeatedly voiced his regret that the U. S. Geological Survey was not continuing ore deposit studies in the State.

Shortly after Congress passed an act authorizing cooperative topographic mapping with states, counties, and municipalities, Mr. Trask, through his friends George A. Stahl, chairman of the Colorado Mining Association, and Bulkley Wells, prominent mine operator and member of the association, together with M. B. Tomblin, secretary of the association and of the Colorado Metal Mining Fund, fostered a bill in the Colorado Legislature of 1922 for an appropriation of $25,000 for the biennial period for cooperative topographic mapping. The first maps made under this agreement were the Pagosa Springs quadrangle on the scale of 1:125,000, so that Whitman Cross might complete his 30-year study of the San Juan region. Another topographic map was the Denver Mountain Parks sheet on the scale of 1:48,000. Another was the Montezuma quadrangle, and still another the Fraser.

In the meantime, Augustus Locke, of San Francisco; Ben Stanley Revett, of Breckenridge, Colo., then sojourning in San Francisco; and Charles G. Yale, in the San Francisco office of the United States Geological Survey, were conferring on the idea of a geological program for some Western State to spend $50,000 a year for five to ten years under private supervision. The choice of the State finally hung on the suggestion of Mr. Yale that Colorado was geologically minded and that it had the most nearly complete statistical data of any State, so necessary for the beginning of geological work. Augustus Locke came to Colorado and laid his proposal before the Colorado Mining Association, urging the need of such work if Colorado were to continue its record of mine production. Mr. Locke used Dr. B. S. Butler's U. S. G. S. Professional Paper 111 of Utah as a sample of the proposed work. The mine operators of Colorado were averse to having this work done by outside geologists but were willing to have the United States Geological Survey continue under its well-known rules that United States geologists were not allowed to invest in mines which they had studied and that they were not supposed to resign and work privately in any State for two to three years after resignation. Augustus Locke also urged that Dr. B. S. Butler, of the United States Geological Survey, who was then completing a five-year job in the Lake Superior region of Michigan, should be chosen for the direction of the work. The Colorado Mining Association accepted Mr. Locke's suggestion and Dr. B. S. Butler and others arrived in Denver July 1, 1926. Office space was not available in Government buildings in Denver, but the trustees of the Colorado School of Mines, at the suggestion of President M. F. Coolbaugh, offered free accommodations at the School in Golden. This splendid cooperation has continued for nine years.

Joint activities of Federal and State agencies result in continued geological studies to the benefit of the mining industry

In the meantime Mr. Trask used his influence to dig out of the files of the United States Geological Survey at Washington the resurvey manuscript of the Leadville district, upon which S. F. Emmons and John Irving had been working more or less continuously for 25 years. Dr. G. F. Loughlin, of the United States Geological Survey, was set to work to bring that manuscript up to date, and Professional Paper 148 was published in 1927. About that time discoveries of oil were made in Colorado at Fort Collins, Larimer County, and in Moffat County, and both good and bad oil promotions were launched. To safeguard the public from making bad investments, and to promote good exploration in eastern Colorado, Mr. Trask exerted pressure to have the United States Geological Survey make a survey of eastern Colorado. This resulted in revision of the geology of northeastern Colorado, wiping off the supposed existence of 1,800 ft. of the Laramie formation and part of the Fox Hills formation, and resulted in the discovery of the Fort Morgan oil field.

In the meantime (1929), the Colorado Scientific Society, founded in December, 1882, was revived, with John W. Finch, now Director of the United States Bureau of Mines, as president. The Colorado Scientific Society had been organized by S. F. Emmons, Whitman Cross, W. F. Hillebrand, of the Rocky Mountain Division of the United States Geological Survey, with headquarters in Denver in the early 'eighties, together with other scientific men such as Anton Eilers, Nathaniel P. Hill, the Rev. H. Martyn Hart, Herman Beeger, J. B. Grant, Richard Pearce, A. H. Low, P. H. van Diest, and A. von Schulz. Just as the first report of the Cripple Creek district was published in Volume 4, 1894, of the *Proceedings* of the Colorado Scientific Society, results of the new geological program have been published in the same medium, beginning with Vol. 12 (1929-31) and now continued to Vol. 13, No. 6, pp. 219-435, "Geology and Ore Deposits of the Cripple Creek District of Colorado." In other words a medium of publication was necessary for this geological survey, and the reputable Colorado Scientific Society filled that need.

During the period 1921 to date the State oil inspector, James T. Duce, under proper authority of the act which created his position, furnished $25,000 for the topographic mapping of 900 square miles of oil shale territory. The Denver Water Board furnished cooperative money for the topographic mapping of Lost Park, with geological examination, and also a topographic map of the region from Grant to Keystone and geological examination of the area through which the proposed Blue River diversion tunnel may be built.

The topographic map for the original Leadville Survey, U. S. G. S. Monograph 12, 1886, was done on the scale of 1 in. equals 800 ft. The topographic resurvey of the Leadville district was done on a scale of 1 in. equals 1,000 ft., as was the Central City topographic map, for the geological base. The early wisdom of S. F. Emmons as to the scale of map for geological examination was repeated by Dr. B. S. Butler, who insisted that for adequate geological examination there must be a topographic map not smaller than 1 in. equals 1,000 ft. Maps of the Climax area and of the Ouray - Telluride - Silverton area have been made on that scale and found none too large for the proper mapping of geology in the search for orebodies. The compromise 1 in. equals 2,000 ft. map for the Mosquito Range geology has greatly handicapped that work.

CHARLES W. HENDERSON.

NEWS OF THE INDUSTRY

Mexican Labor Disputes Checked by Arbitration—Mining on Upgrade

Trend of Strikes Decreases as Operations in Most Mining Districts Show Increased Activity—The Fresnillo Mining Company, in Zacatecas, to Employ More Men for Mines and Hydro-electric Plant

INCREASED ACTIVITY in several regions and a tendency toward arbitration rather than strikes to settle labor disputes were features of early summer events in the Mexican mining industry.

Selection by both sides of Jeraro V. Vazquez, an attorney, chief of the federal labor department, as arbitrator, suspended a strike movement of employees of the El Oro and Tlalpujahua units, in the State of Mexico, of the Cia. Minera Dos Estrellas, S. A. The workers are demanding increased wages, holidays and an annual vacation with pay, free medical attention for those who are ill or suffer non-professional accidents, and pensions for employees who round out fifteen years of continuous service.

The Fresnillo Company has sent out a call for more miners to aid in increased work it has undertaken in its mines near Fresnillo and San Felipe, Zacatecas, and for men to operate the hydro-electric plant it has commenced to install at its Cinco Hermanos mine, near Zacatecas City. The smelter at Matehuala, San Luis Potosi, has reengaged all workers laid off during the depression and is seeking more employees, as its activities have greatly increased.

✦ Work has been resumed on the Quechultengo and Mochitlan mineral tracts, Guerrero state, which were long abandoned. Numerous applications for permits to exploit mineral deposits, chiefly gold and silver, in El Arenal, Chico and Pachuca municipalities, Hidalgo state, have been received by the ministry of national economy.

✦ Conferences with a view to eliminating labor disputes between Lane Rincon Mines, Inc., operating in the Temaxcaltepec district, State of Mexico, and its workers are being held in Mexico City, under auspices of the federal labor department. The principal dispute is a strike threat made by 1,500 workers of the company's El Rincon mine, who demand higher wages. Opposition to the petition filed by the Cia. Minera de San Jose de Maranon, S. A., for authorization to suspend working its mines in the Sabinas region, Coahuila, lodged by its employees, is being considered by the federal board of conciliation and arbitration. The board is also considering complaints of unjustified dismissal made by a group of former employees of the Temixco, Guerrero, unit of the Cia. Minera de Penoles, S. A.

Strike Settlement

After a suspension since February, caused by a strike, work has resumed in mines in the Etzatlan district, Jalisco, operated by the Amparo and Piedra Bola Mining companies, following an agreement reached before the federal labor department between the companies and their employees. Wage increases of from 15 to 20 per cent, extra pay for Sunday and holiday work, eight days' annual vacation with pay for each year's service, and free lamps, helmets, and other mining accoutrement for all underground workers were among concessions the companies granted. The companies also agreed to pay the miners 20,000 pesos (approximately $5,600, U. S.) for the time they lost while on strike.

✦ Mining companies in the State of Chihuahua that operate aviation services must replace all foreign pilots and other members of the crews of their planes with Mexicans, the Ministry of Communications and Public Works has ruled. This order is in compliance with a law which demands that only Mexicans can man commercial planes that are in regular service.

✦ Mexicans have been granted concessions to exploit the following mineral lands in Tamaulipas: La Sabina tract, Llera municipality, and the El Moraleno, La Cueva del Castillo, and La Gonzaleña tracts, in Villa de Casas municipality. All these tracts have gold, silver, lead, and zinc deposits, the Ministry of National Economy says.

✦ The second fraction of the Salinas de Cuyutlan tract, near Cuyutlan, Manzanillo municipality, Colima, has been ordered incorporated in the national mineral reserves, as it was abandoned by its concessionaire, the Ministry of National Economy announces.

✦ The national economy ministry reports that smelters of the Cia. Metalurgica de Peñoles treated 567,150 kg. of silver-lead ore during the last week of June, and mines of Durango, mostly those in Durango municipality, shipped 54 carloads of ore to smelters in Monterrey Nuevo Leon, during the same period.

✦ Cia. Minera de Peñoles, S. A., has begun work in its La Suriana mine and Temisco metal treatment plant, near Arcelia, Guerrero.

✦ The Republican Mining & Metal Company has extended operation to Cuencame municipality, Durango.

✦ Cia. Minera de Panuco has made a contract wiah the Cia. Explotadora de Metales, S. A., to work its mines and metal treatment plant.

✦ Work has been resumed on the Xochitl, San Antonio and San Vicente mineral tracts in the Sombrerete zone, Zacatecas.

✦ Mexico's silver production during the month of June, according to an estimate of the American Bureau of Metal Statistics, was 5,600,000 oz. This represents a slight decrease from the previous month. The world's production of newly mined silver reported by the Bureau for the first six months of this year was 94,518,000 oz. Mexico's share of this total is reported to be 35,631,000 oz. or approximately 38 per cent, which is the largest amount credited to one country. It is hoped that most of the Mexican labor strikes effecting silver mining, will soon be settled, thereby making a steady increase in silver production possible for the rest of the year.

Rocky Mountain States Creating New Wealth From Old and New Mines

Rehabilitation of gold and silver mines and construction of new mills contribute to the upward trend of the mining industry

A SPIRIT OF OPTIMISM appears to prevail in the Cordilleras as each month marks a steady improvement in the upward trend of the metal-mining industry. Gold and silver prices have stimulated investigation of many old mines, the results of which are now becoming more apparent in the active construction of new surface buildings and new mills. The base-metal producers seem to be preparing for better days which they believe lie ahead. Progress like this makes interesting news from the mining states.

IDAHO

✦ The 600-ton hoist, for use at the new 3,100-ft. shaft of Sunshine Mining, is now being assembled. Trucks are bringing the hoist to the property from Butte. The equipment is capable of hoisting ore from a depth of 5,000 ft. Work on the shaft is advancing rapidly, the tunnel to the station being completed and the raise to the surface almost finished. Rich ore was reported to have gone to the mill this week, the concentrator turning out 25,000 oz. of white metal in one day from mill feed said to have reached 55 oz. to the ton. At this rate the goal of 5,000,000 oz. for the year set by Manager Frank Eichelberger will be easily accomplished. The new 3,100-ft. shaft, in addition to hoisting the ore from the Sunshine veins, will also be the main working shaft for Sunshine Consolidated, which adjoins the Sunshine property on the west. A drift into Sunshine Consolidated ground from the 1,700-ft. level of the Sunshine shaft is reported to be nearing the line between the two properties. Manager Eichelberger of the Sunshine is directing the work for the Consolidated, the control of which is said to rest with parties closely affiliated with the Sunshine operations.

✦ An intensive development campaign is under way at the property of the Mineral Mountain Company on Spring Gulch, according to Fred Theil, president of the company. The new bridge at the mouth of Spring Gulch will be completed in a few days, and the road to the lower workings is ready for use. A compressor and power plant will be installed as soon as the bridge is completed. The lower tunnel is being driven by hand mining until the machine drills are available.

✦ The surface plant at the property of the Globe Silver, on Big Creek, will soon be completed and ready to receive the compressor and other machinery designed for use in the lower tunnel. Manager John Mattson has a crew of twelve to fifteen men on the job and expects to push the work in the tunnel with adequate drilling equipment.

New Mill To Dress Up Cripple Creek

Construction of new mills is a natural result of the present intensification of gold and silver mining in many districts. One of the oldest known mining districts is Cripple Creek, in Colorado, which is illustrated and described in this issue. A modern 500 ton mill is now under construction by E. L. Sweeney, of Denver, for the Cripple Creek Milling Company, which will treat ores principally from the Stratton Estate. The plant will consist of three sections, the first having a capacity of 275 tons for one class of ores to be crushed and treated by flotation. The second section will be of 125 tons' daily capacity, which will crush and treat by flotation another class of ore. The filtered concentrates from these two sections, together with 100 tons of raw ore, will be roasted. The roaster calcine will be reground and treated in a cyanide plant of 125 tons' capacity. All buildings will be built of steel and completed about Oct. 1.

✦ The Texas group of claims at the head of East Eagle Creek will be under development this summer, according to Ida Davey, chief owner of the property. A shipment of hand-sorted ore is now on the dump, and it is planned to move this to the smelter when the road is passable. The claims were located years ago by William Davey, who started development operations and opened a good showing of silver-lead ore.

✦ Installation of larger equipment at the property of the Coeur d'Alene Mines Corporation, owning the Mineral Point mine, near Osburn, will permit increased activities and employment for a larger crew of miners, according to H. T. Harding, Seattle, vice-president of the corporation. Excellent ore is being exposed in the drift on the 3½ tunnel level, where the diamond drills indicated the presence of a commercial body of silver-bearing material.

✦ Reports of a gold strike, carrying metal of 75c. at the grass roots, and $2 a yard in the channel, have stirred mining activity again in Jordan Creek, 75 miles north of Mackay. Mrs. E. E. Humphreys, of Palo Alto, an investor in virgin mining districts, is actively interested in the new strike. Plans are being made by promoters for the installation of a $25,000 placer mining machine, which, according to estimates, will recover approximately $1,200 of gold per day.

✦ Operations of the Sultan Gold Company in the Elk City district are progressing rapidly, according to J. E. Jones, Kellogg, president of the company, who has returned from an inspection of the work. The management plans to extend the shaft to the 300-ft. level, where a station will be cut and a drift started on the vein. A crosscut is expected to cut the second vein at a distance of 200 ft. From this new station diamond-drill operations will determine the ore at greater depth. When this work is accomplished plans for a mill will be made. Assays from a 3-ft. vein on the 100 level have been reported ranging from $30 to $50 per ton in gold. This has created the incentive to push the work as fast as possible to open the vein at greater depth.

UTAH

✦ Improved prices in silver, lead and zinc, and stimulated production, have caused the Tooele, Utah, smelter of the International Smelting Company to increase, effective July 3, its lead-smelting operations 20 per cent. From a five-day basis, the operation of one lead furnace has been increased to a six-day basis to care for increased shipments.

✦ At the King David mine, controlled by Tintic Lead, the company is drifting north on the 750 level through a highly mineralized formation, that gives indications of being the casing of an orebody similar to that in the adjoining Horn Silver.

✦ Shipments are being made from the Honey Boy mine. The Beaver Crown property is also productive. The Frisco Silver Lead Mining Company has installed a 25-hp. gasoline engine to assist in the sinking of the new shaft, sunk to a depth of 125 ft. by hand. A new headframe has been erected and a compressor installed.

✦ Operations have been resumed at the property of the Leonora Mining Company in the Star district, as the result of the improved price of silver.

✦ Recently, Beaver County mining men assisted in the circulation of a petition asking the U. S. Forest Service to build a road up the South Fork of North Creek, a distance of 9 miles, to aid mining operations in the area.

✦ A new 225-hp. double-drum electric hoist is being installed by the Park City Consolidated Mines Company at Park City, under the direction of Gloyd M. Wiles, general superintendent. The shaft will be raised about 60 ft., so that the new plant can operate on the surface rather than from the adit. Retimbering of the main winze from the 400 to the 900 level is well under way and sinking below the 900 will be started on or about Aug. 1.

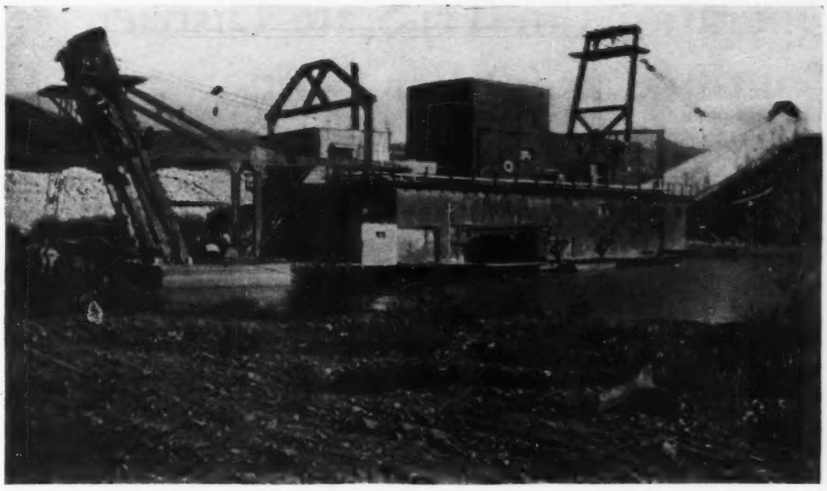
✦ The New Park Mining Company has started operations in a new sector of its property to develop the showing opened years ago in the Pearl fissure about 400 ft. from the portal of the Star of Utah tunnel. Driving of the Mayflower tunnel is being continued.

✦ Operations at the Eureka Lilly mine in the Tintic district are producing from 2 to 3 carloads of gold ore below the 1,300 level. Work in the Tintic Gold property, recently resumed, is being focussed on the Ajax fault zone on the 600 level.

✦ Arrangements have been completed at the Zuma property for a resumption of development. Work of retimbering and cleaning out the headings, preparatory to resumption, has revealed several promising showings, according to President W. F. Shriver.

✦ Shipments are being made of a high-grade silver-lead ore from the Columbus-Rexall mine at Alta in the Little Cottonwood district. The Flagstaff and West Toledo mines are also active.

Melted snow in the Rocky Mountains provides ample water for hydraulic gold mining near timber line



A large gold dredge near Breckenridge, Colo., operating in gravel considered unprofitable years ago. Many old buildings in lower Breckenridge have been razed to make way for gold dredging

✦ The Ophir Midland property, at Ophir, is also producing at the rate of a carload a week from the Fiske tunnel. A raise on the Monster fissure from the Gem tunnel is following a strong ore showing to the intersection with the Dixie fissure a short distance ahead.

✦ A power line has been extended to the Prince of Wales tunnel of the Utah Ophir Company and surface buildings completed preliminary to augmented exploitation of the company's ore showings.

NEVADA

✦ Operations on the 600 level of the Mountain City Copper mine of the International Smelting Company at Mountain City, Elko County, Nev., have been temporarily suspended for development of the orebody on the 500 level and above. On the 600 level, the company opened up an orebody 60 ft. wide, carrying 2 to 10 per cent copper. Ten feet of the ore ranged in value from 10 to 12 per cent copper. Having now more ore developed above the 500 than it can market for some time, the company decided to pull the pumps on the 600 and center development on the upper levels of the mine.

✦ The East Standard Mining Company is now treating 12 tons daily at its Midas, Nev., plant. This ore is coming from old mine dumps on the property. At the same time, the lower tunnel is being advanced steadily, according to Manager Harry S. Joseph, to cut the downward extension of the orebody from the upper levels 300 ft. under the lowest working. The property has an ore zone 200 by 600 ft. developed only to a depth of 100 ft.

✦ The Weepah-Nevada Mining Company has awarded a contract to the Southwestern Engineering Company, of Los Angeles, for the construction and equipping of a 250-ton amalgamation and flotation plant. Location of the mill is near the open-pit Electric Mine, Weepah. Water for plant operation will be delivered to the mine by a new 7-mile pipe line.

✦ With the addition of ore-washing equipment, Nevada Lucky Tiger, subsidiary of Lucky Tiger-Combination Gold Mining, has been treating 50 tons of gold ore per day in its cyanide mill at the Buckskin National mine, in northern Humboldt County. The mine, owned by Buckskin-National Gold Mining, is being worked by the Lucky Tiger under a lease arrangement involving equal division of net proceeds between the companies.

✦ In reopening an old tunnel on the Xerxes group, near the Como Mines property, and extending the adit a short distance, a vein of much promise is said to have been exposed and a crew of miners will start at once to drive on the vein. The property has been acquired by a group of men in Nevada and from the East.

✦ Engineers of the PWA, following a conference with representatives of the Pioche power district, have indicated that they will approve a PWA loan of $1,120,000 for the construction of a 144-mile power line from Boulder dam to Pioche, where mine owners purpose to expend several millions in smelter construction and mine development. At the conference were J. L. Vandiver, PWA engineer; J. A. Buehler and Edward Snyder, of Combined Metals Reduction; J. G. Scrugham, Congressman from Nevada; Wallace Campbell and Jesse Evans, financial and legal PWA advisors.

✦ The fourth 30-ton shipment of gold-silver concentrate from the new 350-ton flotation mill of Como Mines, south of Dayton, has gone by motor trucks to the Selby smelter. The product is said to have a value of around $140 per ton.

Operations in Tri-State District Continue at 90 Per Cent

Attempts of Strikers to Prevent Opening Lead Smelter of Eagle-Picher Mining & Smelting Company Brought a Return of the National Guardsmen

RIOTING broke out in Galena, Kan., on June 28, when an attempt was made to reopen the lead smelter of the Eagle-Picher Mining & Smelting Company, which had been closed by the strike of the International Union of Mine, Mill, and Smelter Workers on midnight, May 8.

The attempted reopening of the smelter, which is located just west of the Missouri-Kansas state line, brought an organized attempt not only to halt the reopening of the smelter but to prevent many workmen living in Missouri from going to work in the mines of Kansas and Oklahoma on the morning of June 28, as strikers lined the state line for a distance of several miles and blocked all efforts of miners to reach their place of work.

The new uprising brought the return of the Kansas national guardsmen, most of whom had left the district on June 26. Colonel Charles H. Browne, in charge of the troops, immediately proclaimed martial law in Cherokee, Kan., and the situation became quiet.

No arrests had been made by city or county officers during the day of rioting, although six deputy sheriffs were stationed along the highway during the day in plain sight of the stoning and shooting of cars. Colonel Browne penalized the rioters and set up a military court, which sent more than thirty persons to the county jail for terms ranging from fifteen to sixty days.

Troops were withdrawn from Cherokee County on July 20 with the exception of Major Ellis Christensen and one other officer. Martial law will be continued for an indefinite period, however.

The smelter was reopened on July 23 without difficulty. The plant was employing about 150 men at the end of the first week's operation, or slightly more than 50 per cent of the number working at the time of the strike. Company officials expect to have the plant soon working at capacity. Fifty mine and tailing mills have resumed production since June 3. This is four less than were operating before the strike. Zinc production is now about 90 per cent of normal.

American Mining Congress
Metal Mining Convention
Palmer House, Chicago, Ill.,
September 23-27—1935

✦ The Early Bird tailing mill of the Semple Mining Company, which has been idle for many years, has been reopened. The plant has been completely renovated and operation will soon be started.

✦ Little Chief Mining Company has purchased the Easy Money mine, near Diamond, Mo., from George Moore and associates, for $40,000. H. M. Hurley is manager of the company. The mill is being rebuilt and is expected to be in operation before Aug. 1.

✦ Frank Childress and associates, who are dewatering the Oronogo field in the old Missouri section of the Tri-State district, installed a new Pomona pump, with a capacity of 6,000 g.p.m., in the latter part of July to combat the heavy flow of water that had been greatly augmented by the abnormally heavy rains of the past two months. The unit is driven by a 330-h.p. motor. Four Pomona pumps, with a capacity of more than 10,000 g.p.m., had previously been installed. These pumps were lowering the water at a satisfactory rate up until the middle of May. Heavy rains sent millions of gallons of water into old mine shafts and cave-ins, raising water levels at all points in the old field.

The Bird Dog Mill of the Commerce Mining & Royalty Company, 2 miles west of Picher, Okla. Ore is ordinarily collected and transported from four shafts over a railroad 2.3 miles long to this central mill

MICHIGAN

✦ At the Calumet & Hecla Consolidated's Ropes gold mine property, near Ishpeming, Mich., 22 men are employed, in two shifts. The mine is comparatively free of water and the pumps are used only at intervals. The shaft is bottomed at 822 ft. and drifting has been started east and west at 812 ft. Later a series of drill holes will be made to the north and south from the drifts. The shaft is in good condition, and surface equipment required at present is in working order. Development work will be watched with interest.

✦ In the same district, sinking has been started in the Michigan gold mine from a depth of 83 ft. The shaft will be sunk 200 ft. additional, with several levels. Operations consist of three shifts in which 25 men are employed.

MINNESOTA

✦ A cheerful attitude is felt throughout the Mesabi range, as the ore demand shows no let-up and production continues according to plans made in the spring. Ore shipments at head of the Lakes docks for the first six months of this year totaled 6,998,465 tons, an increase of 1,062,155 tons over the corresponding period a year ago.

✦ The Argonne Ore Company is showing activity at the Dunwoody mine, near Chisholm. Part of the 600,000-ton ore pile has been moved to accommodate a 100-ton-per-hour washing plant that will be installed immediately and operated the remainder of the season.

✦ John A. Beecroft, a former safety inspector for the Pickands Mather Company at Keewatin, has been appointed mine inspector of Itasca County, to succeed W. J. Truscott, who died on May 4.

NEWS FROM WASHINGTON

By Special Correspondent

CAMPAIGNING against bigness is now the major activity of official Washington. The New Deal banner now carries the legend "Bigness is Badness," and demagogic appeal is rampant.

The new tax program intended to soak the rich is only one evidence of the trend. And there is no question but that higher levies will be placed on all large incomes, gifts, and inheritances. The corresponding effort with reference to corporations, discussed in a succeeding paragraph, is another pretty colored piece of the same jig-saw puzzle. It is a queer-shaped one, but it fits a hole in the Administration program with ease and perfection.

All kinds of insurgent groups are coming to Washington for amplification of their otherwise feeble voices. The merchandising group which opposes chain stores came recently and brought a bill which even the proponents did not anticipate would have sweeping effect on mining, manufacturing, and other business. Sales discrimination between customers in any way as to price or other terms for a given quantity of goods would be forbidden, were this legislation enacted. And, furthermore, any price differentials based on quantities greater than a single carload lot would have been taboo. The *objective* was obviously to give the independent merchant equality in purchasing power with the chain; but the *effect*, if enacted, would have broken down several customary practices of mineral merchandising.

Opposition to this effect on the part of groups not involved in wholesale and retail sale of consumers' goods is expected to narrow the legislation rather promptly. The anti-chain workers are going to have troubles enough making any progress if they redraft their wishes so that only the narrower field is affected. But the movement is all too typical of Washington. Even though the individual bill (H.R. 8442) ceases to have significance for the mining industry, there will still remain the clearly evident desire to break down by legislation all established practices in which bigness finds any particular advantage.

Another group, aggrieved by the cross licensing of patents in their several industries, has undertaken a campaign to secure restriction on that form of business efficiency. Several legislative moves have been made, including most significantly an effort to bring under Senatorial inquisition the industrial groups using cross licensing, the equivalent of a patent pool. Mineral industries are somewhat less affected in this case, but are certainly significantly concerned in any such trend, if it gains strength, as it would forbid contractural cooperation by what are now legal means for pooling and exchange of patent rights.

Easy Money

Washington influences are all strongly in the direction of lowering the cost of money to industry. Loans from RFC and the Federal Reserve banks continue regularly, but only to a limited extent in the mining industry because of the difficulty of qualifying. The latest lending agency of interest is the Federal Housing Administration, which now offers loans up to $50,000 to industry as an aid to plant repair and modernization. Thus far these loans are not numerous, but in some respects they are easier to procure for mine properties. The money does not come directly from the Government but from the local bank or lending agency, which is protected against loss by the FHA insurance plan.

Loans up to five years with monthly reduction of the principal are planned. The interest charge will not exceed the equivalent of $5 discount per $100 face amount of a one-year note payable in monthly installments. This means about 9.7 per cent at simple interest, but still the cost of the money for the hard-up modernizer may be materially less than hitherto. Enterprises with several plants may borrow up to the limit of $50,000 on each establishment. Furthermore, the modernization idea includes purchase and installation of new machinery and equipment, as well as actual repair expenditure.

Resource Surveys

With the substantially increased appropriations for this fiscal year, the United States Geological Survey contemplates a general increase in its customary resource and field investigations. Perhaps the most important new project provides for a complete restudy of the Comstock lode, using intensive modern geologic methods not hitherto applied to that famous structure. Another study soon to be undertaken will be a resumption of the inquiry interrupted two years ago in the Eureka, Nevada, district. There is some hope that in the southern part of this territory gold occurrences may supplement and make economically workable the otherwise submarginal silver-lead deposits.

A number of projects under way last year in the field work of the Survey will be conducted on a larger scale this year. In Idaho a number of the potential placer deposits in the old tertiary basin are to be mapped. Alluvial gold is, of course, the objective. Similar studies of basins potentially workable by dredging will be considered in Montana. New geophysical methods are to be applied to the tungsten of Boulder County, Colo., on which a report should be completed within a year.

The final field geology and the office work done by the Survey on the Boulder Dam territory has been completed. The report of this project will be a substantial amplification of the preliminary report issued a few months ago by the Reclamation Service, but based on U.S.G.S. study. It is anticipated that the full report when issued will not carry any substantial new implications or justify any change in conclusions from the original document. The recommendation for a like study of the mineral resources in the territory tributary to the Bonneville, Oregan, dam has not been approved.

Reform by Taxation

Reform, not revenue, was the unquestioned purpose of the President's tax proposals which stirred official Washington to turmoil throughout July. But Congress writes its own tax bills, is thoroughly competent to do so; and when a tax measure is finally enacted it will be for revenue raising first and reform effort only secondarily. However, there are enough members of Congress interested in reform to make sure that some of that constituent will be found in many sections of the new tax bill.

Of greatest concern in the mineral industries is the proposal that the tax on corporations shall be graduated accordingly to the size of the income. Initially, Congressmen were badly confused by his proposal, and a number were disposed to believe the President's absurd claim that the larger an enterprise's income the greater its ability to pay taxes. But the fallacious reasoning which underlay that reform-inspired idea was soon recognized on Capitol Hill as both erroneous and politically inept.

The President unquestionably wishes to establish a new principle of taxation of corporations. Initially he was in fact very little interested in whether more money came to the Treasury or not.

Once he could get the new principle into the law—of higher rates on bigger incomes—then changing the rates in the law would be easy. This probably explains why there was so small a spread proposed by Administration spokesmen between the tax rate on small corporations and on big. The hope was clearly to make the small differential seem innocuous while the principle was being fixed.

Mining is peculiarly the affair of big business. Small units for most important metals and minerals have little economic opportunity. Furthermore, the small units could not be salvaged by this New Deal style of taxation. Unanimous and enthusiastic opposition may, therefore, be expected from the mining industry; in fact has already been evidenced by its Washington spokesmen.

The widely successful effort of food manufacturers to suspend processing taxes has importance for the mining industry, as for every other important division of industrial taxpayers. The effort widely successful in trial courts, and less frequently but none the less surely in circuit courts of appeal, will go to the Supreme Court for settlement in the fall. But no decision is expected until about Christmas time. If the Supreme Court rules that these processing taxes have been imposed unconstitutionally, as well-informed Washington lawyers generally expect, then Uncle Sam will find a $600,000,000 leak in his purse. No one expects that farm benefits will cease. Raising of the huge sum necessary to pay them must, therefore, be accomplished by other means than the present processing taxes. A budget jolt of that size is of importance to everybody.

FTC Codes

Projects for industry code making continue to progress only under the Federal Trade Commission plan. The old-fashioned Hoover-promoted scheme of trade-practice conferences is being revived by the pulmotor of necessity. Only that scheme gives any promise of legalizing industry agreements that the New Dealers want.

The American Federation of Labor still insists on a plan for licensing industry which would virtually close the channels of interstate commerce to any goods produced in a non-code establishment. In late July no one has very much confidence in any of the schemes for establishing minimum wages, maximum hours of work, or other employment conditions. The more they study the situation, the more confident officials become that the Supreme Court has definitely proscribed all of that so far as Federal activity is concerned. The desire and the hope still remain, though the expectation of success is weekly declining.

Few cases of flagrant violation of the late code agreements as to employment are being found. Reformers are patently disappointed and the demagogs deprived of their best megaphone.

Anti-trust suits glibly forecast by disgruntled reformers are not likely to materialize soon. There can be no better evidence of this than the selection of John Dickinson, recently Assistant Secretary of Commerce, to head the anti-trust unit of the Department of Justice. Dickinson, though a professor and thus eligible to the supreme council of the New Deal lodge, is not a crusader against bigness. He is expected to make a fearless, but intelligent, application of the Sherman, Clayton, and other trust-busting laws now on the statute books. Such a program need inspire no fear on the part of cooperating industry executives who seek merely effective collaboration and maintenance of trade decencies. "But," Dickinson's friends say, "let the price fixers beware!"

Gold and Silver

The hardy perennial of compulsory rapid silver purchase by the Treasury blossomed again in late July under the stimulus of silver-state Senators. This time, led by Senator McCarran, Democrat, of Nevada, this legislative bloc is demanding "that a definite silver remonetization should be effected as soon as possible. We feel that the Treasury either should go ahead with its purchasing program until the price reaches $1.29 an ounce or until one-fourth of the monetary reserve is made up of silver. This was the intent of the 1934 silver purchase act, but that act contained no mandatory purchasing provision."

Soviet Trade

Most spectacular of the new trade agreements negotiated by the State Department is the Russian agreement re-establishing orderly trade relations between U.S.A. and U.S.S.R. The prompt and confidently to be expected protests of the domestic manganese producers afforded only another excuse for sarcastic response at the State Department. The President has commented on the manganese industry's objections to the Russian agreement. And his comment brings out the fundamental philosophy underlying some the mineral tariff negotiations now in progress. If the United States were to produce its own manganese supply the result would be, according to the President, ten, twenty, or fifty times the increase in the cost of steel which would be involved in all the wages paid to manganese miners. This, he regards, as much too high a price to pay for domestic development. Furthermore, he says, the increased purchasing power abroad created by such an agreement as that with Russia will bring business to the United States and furnish jobs for ten times as many persons now idle as would possibly be put to work if the manganese industry of the United States could run at the peak ever attained even in war times. Like reasoning may be expected from the Administration with respect to other metals and minerals involved in tariff trading.

Enlarged Soviet purchases in America will undoubtedly result, and substantial increase in imports of Soviet products are inevitable. Brazil, British India, and the African Gold Coast may, therefore, not reap the expected benefit from the recent 50 per cent cut in the manganese tariff. Russian production may well secure most of the benefit. Of course, all this assumes that Brazil does ratify its agreement so that it may take effect. Evidently, the legislators of that nation do not always follow promptly the steps of their diplomatic negotiators any more than does the United States Senate. The principal benefits to American industry are, of course, expected in the fields of machinery, automobiles, and other highly fabricated products of manufacture.

More tariff agreements are being negotiated, and new announcements with other nations may be expected at frequent intervals. Nobody knows, therefore, whose tariff will next be cut.

Labor Policies

Perhaps the first "final" test of Federal labor policies will come through enactment and court review of the Guffey coal bill. This will have interest for all mineral industries, as the principles involved in coal regulation do not differ essentially from those affecting metals and non-metallics.

The President's request that the Guffey bill be enacted regardless of "any doubts as to constitutionality, however reasonable," has inevitably roused much criticism. Tory critics, of course, make all sorts of charges against the President, claiming that such an effort is a violation of his oath of office to defend the Constitution. That claim would presumably be laughed off by everyone were it not for the fact that on several previous occasions the President has referred slurringly to the courts, particularly to the Supreme Court. Something of a political issue thus arises.

The Administration is attempting by the Guffey bill to build up a case in support of a constitutional amendment giving more authority to the Federal Government. Some even allege that the President would like to have a half dozen major New Deal ideas thrown out by the Supreme Court so that he would have an equivelent number of large groups of society ready to support him when he formally asks Congress to initiate a constitutional amendment. Such imputed motive, of course, cannot be proven, but it is, none the less, widely accepted as believable.

Valuation of Arizona Mines Boosted—Strikes Continue

Eight Properties Are Added to the State's List of Metal Producers—Production at Copper Queen Not Affected by Strike—Phelps Dodge to Install a New Reverberatory Furnace at the Douglas Smelter

THE assessed valuation of Arizona's producing mines has been raised $18,196,076 by the State Tax Commission, an increase of more than 100 per cent over the 1934 valuation.

The increase chiefly was brought about by addition of eight properties to the "producing" classification.

One mine already on the producing list, the Copper Queen branch of Phelps Dodge at Bisbee, was increased $1,553,923 above the $12,000,000 valuation of last year. The valuation of the United Verde Extension Mining Company was reduced from $500,000 to $239,475.

The total assessed valuation of producing mines was set by the Tax Commission at $33,908,453, as against $15,712,377 last year.

Assessed valuations were listed by the commission as follows:

Cochise County—Phelps Dodge Corporation, $13,553,923; Shattuck Denn Mining Corporation, $250,000; Tombstone Development Company, $100,000.

Gila County—Miami Copper Company, $2,897,060.

Mohave County — Gold Standard Mines Corporation, $25,000; W. M. Whalley and C. F. Weeks, $22,800; Big Jim mine, $50,000.

Pima County—Phelps Dodge New Cornelia branch, $13,670,195.

Pinal County—Magma Copper Company, $3,000,000.

Yavapai County—United Verde Extension Mining Company, $239,475; Hillside Mines, Inc., $100,000.

✦ Sporadic outbursts mark the strike at the Copper Queen in Bisbee. There has been no interference with production and no increase in the number of strikers as the strike moves into its second month. A striker was wounded by a company guard in the only gunplay at the mine. Busses have been stoned and workers beaten, but most activity has been confined to picketing.

✦ Phelps Dodge will spend $250,000 for a reverberatory furnace, 26x107 ft., and a waste-heat boiler of 2,700 hp. at the Douglas smelter. This will replace an old furnace, but plant capacity will not be increased.

✦ Edith claims, near Kingman, are producing 250 tons a month. Dewatering of the 200-ft. shaft will be followed by development work at lower levels.

✦ Elzo Mining is down 90 ft. in the 150-ft. shaft on the claims in the Arivaca district. Flotation cells are to be added to the gravity and amalgamation units now operated as a custom mill by Elzo D. Smith.

✦ Black Canyon Mining is milling ore from the Thunderbolt mine, at Cleator. Lack of adequate water supply is limiting output to about half of mill capacity.

✦ Cornwall Mining, Mineral Park district, is shipping horn silver ore from the shallow workings. A 50-ft. winze 600 ft. from the portal of the main tunnel has struck ore carrying wire silver.

✦ Kaaba Mining & Milling, Kingman, has made a trial run of its mill, under the supervision of O. W. Little, preparatory to putting the plant on regular production.

Oatman Strike

All but two mines in the Oatman district have been shut down as the operators' answer to a strike called July 1 by the Oatman local of International Mine, Mill, and Smelter Workers Union. The local voted June 24 to call the strike unless wages were raised $1 a day above the present $4.50 (at the instigation of an organizer from Butte). Within 48 hours the mines began to shut down. By July 1, only Big Jim and Mossback had raised wages, and therefore continued to operate. Officials of Tom Reed stated that a fair wage was being paid and that the expected profits this year would be the first available for the shareholders, who deserved some consideration. The closing of the Tom Reed mill prevents many lessees and independents, who would not be affected by the strike, from shipping their ore. No violence has been reported. The strike has not spread to the Katherine, Chloride, or Weaver districts.

✦ Mammoth-St. Anthony has joined the ranks of producing mines by sending 100 tons a day to the newly enlarged mill of Molybdenum Gold. E. A. Stone is mine superintendent and S. R. Burdick, chief mine engineer.

✦ Gold Divide, at Crown King, has completed installation of a 350-ft. compressor, 60-hp. gas engine, gallows frame and hoist, water tank, and camp houses.

✦ Amulet Operating Company, Prescott, has increased flotation capacity from 35 to 150 tons, and is now milling 100. The 200-ft. shaft is to be deepened to 500 ft.

California Mines Sinking To Deeper Levels

In the Nevada City area, Empire Star Mines is sinking the main 1,600-ft. shaft at the Murchie mine to 2,000 ft. preparatory to opening up new levels and starting development work at that depth. The flotation plant is treating about 350 tons of ore a day.

✦ Rehabilitation work is progressing satisfactorily at the Ragon mine, owned by California Sierra Gold Mines, Inc., Orlando McCraney, president. The 225-ft. shaft is being unwatered and repaired, lateral workings cleaned out, and development work is expected to start soon.

✦ At Melones, Carson Hill Gold is now milling 1,000 tons of ore a day at its mill, with mining operations carried on at the Calaveras open cut, and underground from the 300 to the 3,000-ft. levels.

✦ Alterations to be made at the mill of Cardinal Gold Mining Company, at Bishop, include the installation of a cone crusher, which will take the place of a gyratory crusher now in use. The mill is treating about 140 tons a day. At the mine sinking of the 300-ft. shaft to 400 ft., and later to 500 ft., is planned. Hoisting facilities are to be modernized by installation of a double-drum hoist and skips.

✦ Construction of a 2-mile power line, a 1-mile aerial tramway, and a 100-ton mill are in progress at the Oxford mine, near Downieville.

✦ Texas Gulf Sulphur Company is reported to be negotiating for the operation of the property owned by the Leviathan Sulphur Company in Alpine County. A small pilot plant is available at the mine.

✦ Walker Mining Company is making repairs at its mine and 1,600-ton flotation plant, situated 27 miles northwest of Portola, Plumas County, with 20 men employed.

✦ California Copper Corporation, through its subsidiary, Engels Copper Mining Company, is reported to have taken over the management and controlling interest of the Belmont Osborn Mining Company, which owns about 25 acres of mineral land and a 15-stamp mill near Angels Camp.

✦ A 35-ton mill has been placed in operation at the German Bar mine, on the Middle Yuba River, 10 miles from Alleghany.

Nova Scotia Gold Mining Indicates Some Important Developments

Production of Gold in Canada Continues to Swell the Dominion's Exchequer —Province of Ontario First in Gold Production and Quebec and British Columbia Follow—Aluminum Company of Canada Constructing New Refinery

THREE GOLD PROPERTIES in Nova Scotia now show definite evidence of becoming mines of substantial proportions. The Seal Harbour mine has developed an unexpected volume of ore above the 100-ft. level in "belts" that range from 7 ft. to 60 ft. in width. Drifting on the second level at 300 ft. will reach the flat-pitching shoots in these belts. At Goldenville the "belts" are narrower and do not contain so much quartz as at Seal Harbour, but it has now been established by nine months' operation of the 50-ton stamp mill that ore of payable grade exists in large quantity at the property. The capacity of the mill is now being doubled to 100 tons. Ventures, Ltd., is financing the local company, Guysborough Mines.

At Caribou, Consolidated Mining & Smelting, after operating a test mill for six months on ore obtained from the shallow workings of the old mines down to 300 ft. depth and diamond-drilling for formation to over 1,000 ft. depth, has installed an electrically operated mining plant and is sinking a vertical shaft to open a succession of levels from 500 ft. down. Power is being drawn from the Sheet Harbour hydro-electric system 29 miles away. The three properties mentioned in the foregoing are all east of Halifax, at distances of 105, 85, and 45 miles respectively. Elsewhere in the province several small gold operations are under way in the traditional hand-to-mouth fashion.

ONTARIO

International Nickel's plan to concentrate its mining operations in the two properties, Frood and Creighton, leaving the others such as Levack and Garson for future use, is well exemplified in the recent development program at the two mines. The new underground hoist at the 2,800-ft. level of the Frood is conveniently placed to serve the immense deposits of high-grade ore immediately below, and tramming to the present shaft, already equipped adequately for the requisite 10,000 tons daily, is more convenient than tramming on the surface. A new vertical shaft is now under construction at the Creighton to supplement the present inclined shaft. The capacity will be 4,000 tons a day from a 4,000-ft. depth, where it will become a compound shaft to an estimated depth of 7,000 ft. These developments, which are well ahead of current ore requirements, illustrate both the great size of the respective ore deposits and International Nickel's faith in the future of the nickel market, whose continued expansion this added mine capacity is designed to meet.

✦ Falconbridge Nickel has under way a similarly broad plan of expansion, the first stage of which has been to open its ore zone both in depth and length. The original diamond-drilling had indicated ore for a length of two miles, and this has been proved at the 500-ft. level from the eastern shaft for a length of 5,000 ft. The average grade on this level is slightly below that now being treated. The eastern shaft is now at a depth of 1,200 ft. and at 1,400 ft. will be connected with the old shaft 3,000 ft. to the west.

Canada Surpasses Russia in Platinum Metals

Canada's output of the platinum metals, which reached 200,000 oz. last year, now exceeds that of Russia, which has held the lead for many years. This all comes from the electrolytic refineries treating matte from the Frood and Falconbridge ores. Creighton ore is turned into Monel metal, without electrolytic refining. The separate metals produced are platinum, palladium, iridium, rhodium, and ruthenium. Osmium is not produced from the Sudbury ores.

✦ The report of Hollinger for the first six months of the year shows a drop in operating profit to $2,232,451, compared with $3,521,821 in the first half of 1934, and dividends have been in proportion. Recovery per ton was $7.33, against $8.15 last year, this marking the fact that a large proportion of the tonnage is coming from the upper levels of the mine, which have shown an unexpected volume of ore during the re-examination of the past three years. Comparatively little ore is now being drawn from the lower levels, where the average value is much above that of the present mill feed. This policy of cleaning up the upper levels while the conditions are favorable to the treatment of low-grade ore is being pursued by most of the Canadian gold mines.

✦ The first of the silver mines to be reopened is the Morrison, at Gowganda, where Horace F. Strong pursued a vigorous policy of exploration down to 400 ft. depth until the price of silver dropped in 1930. This mine has had only a modest output, but there are indications of a much larger volume of ore at greater depth.

QUEBEC

Quebec appears now to have taken a definite second place among the provinces in gold production. The May output was 36,166 oz., against 29,050 oz. in British Columbia, the Ontario figure being 188,993 oz. With several substantial new mills in operation and some small ones to be enlarged, the Quebec output can be expected to reach a steady 40,000 oz. by the end of the year. This is only half the amount that comes monthly from either the Porcupine or the Kirkland Lake camps; but the Quebec mines are all young, and several of the smaller mines give promise of growing to major dimensions.

✦ Marked activity continues in the eastern end of the gold belt south of Amos and Senneterre. Tiblemont Island, which has interesting results at surface and in an adit at a general depth of 100 ft., has now entered the ore zone at the 500-ft. level. The vein system here, as at Siscoe and other properties, is in a granodiorite with irregular deposits and values confined mainly to coarse gold.

✦ Sullivan Consolidated continues to mine ore of ½-oz. grade or better. As the flat-dipping deposits are, in the third level, too far from the original shaft, a new vertical shaft 1,200 ft. to the south has been started.

✦ At the Sigma property, Dome has disclosed on a more modest scale the good showings of its neighbors, and work is continuing on three levels. Perron Gold's new 100-ton mill, to replace the present 25-ton test mill, is expected to be in operation by the end of the year.

✦ Development of the Chibougamau-Opemiska area has been given another fillip by the decision of the Quebec government to aid Ventures, Ltd., in cutting a 170-mile winter road to Opemiska Lake, with a view to further exploration of the copper-gold showings there, and possibly their exploitation. The terminus is at Rouleau, 70 miles east of Senneterre. Work was started during the latter part of June and will be completed before the freeze-up.

✦ Aluminum Company of Canada has commenced the construction of a $1,000,000 plant for the refining of bauxite by the wet process. This apparently marks the end of the attempt at Arvida to refine bauxite by the dry process, which has been carried on in a deter-

mined way since 1929. The new plant is expected to be in operation in March of next year. The Arvida plant, based on the abundant and cheap power of the Saguenay River and the ready availability of high-grade bauxite from British Guiana, is not yet working to capacity, due to the political restrictions that hamper world trade. There is evidence, however, that the Arvida plant is destined to become one of the world's principal sources of aluminum.

MANITOBA

Following the redemption on July 15 of the last of the $5,000,000 convertible debentures issued to complete plant construction, the directors of Hudson Bay Mining & Smelting Company have declared the first dividend, of 50c. per share, out of earned surplus. This marks the final stage in the development of this great mine, which from its inception in 1929 has been handled with notable skill in all its phases. This initial dividend has been earned in the face of continuous low prices for copper and zinc, the principal products, which have been counterbalanced to only a minor extent by the enhanced price of gold. With very large ore reserves and with a payable operation in spite of low metal prices, the future of the company is assured for many years.

✦ A mining plant, to be electrically driven from the power plant now being constructed to operate the Gods Lake mine, is being assembled on the adjoining Jowsey Island Gold Mines property with a view to opening at the 200-ft. level shoots of ore indicated on surface and by drilling.

✦ Ore of good grade and fair volume is now being opened in Forty Four ground from the long drive eastward on the 600-ft. level of the adjoining San Antonio mine.

NORTHWEST TERRITORIES

The Great Bear Lake boom has subsided into the steady production of one small mine. Eldorado now has developed a sufficient reserve of high-grade radium-silver ore to insure a full supply of hand-picked high-grade ore and concentrate to the refinery at Port Hope, Ontario. This requires at present 200 tons per annum, but the plant is now being enlarged to 360 tons' capacity per annum. The refinery products in 1934 were valued at $595,000, from 4,042 tons of ore, which averages $147 per ton as mined. Ore developed above the 125-ft. level is reported at $2,500,000. The second level, at 250 ft. below the adit level, is beginning to show a similar volume of ore. A small net profit is reported for 1934.

✦ Athona Mines, Ltd., is the new name of Great Bear Lake Mines, whose principal operation is now at Athabaska Lake.

British Columbia Increases Her Importance as a Metal Producer

New Mills Recently Placed in Operation Will Add Substantially to This Year's Precious-Metal Production—Granby Consolidated to Close Copper Mines

IN A REVIEW of the mining industry of British Columbia for the first six months of 1935, Dr. J. F. Walker, Provincial Mineralogist, estimates the value of the production to have been $21,672,674, compared with $20,697,827 for the corresponding period in 1934. The physical volume of the output of gold, silver, copper, and zinc increased compared with the record for the first half of 1934, but only gold and copper production increased as compared with the last half of 1934. The value of lode-gold production would have been about $500,000 greater had it not been for the curtailment of output resulting from the fire at Premier last autumn, and the labor strike at the Bridge River mines in May.

It is anticipated that the production from mills recently put into operation, or under construction, will add about $500,000 to the value of lode-gold production for the last half of 1935. The decline in output of lead and zinc is attributable in large part to the cessation of milling in February at the Monarch, near Field, but operations which were resumed at the beginning of July at the rate of 300 tons a day should result in the total production of lead and zinc for the year approximating the figures of 1934.

Silver production will also increase as a result of resumption of milling at the Monarch, and also because of the bringing into production of several small silver properties. The prospect for large-scale copper production is marred by the decision reached by officials of Granby Consolidated to close the mines at Anyox at the end of July and to dismantle the smelter by the end of August. Dr. J. T. Mandy, Resident Mining Engineer for the district, observed recently that there is apparently a year's supply of ore left in the mine, but obviously this must be non-commercial under the present circumstances.

✦ Another orebody, assaying 1 per cent nickel, has been located by a horizontal bore at B. C. Nickel near Hope. A considerable tonnage of ore has been indicated by crosscutting and horizontal drilling, and a program of vertical drilling has been commenced with a view to establishing reserves definitely.

✦ Bradian Mines, adjoining Bralorne in the Bridge River district, and formerly a part of it, is to be merged into the parent company for the purpose of greater efficiency in the operation of the two properties under prevailing conditions. The capital of Bralorne will be increased from 1,000,000 to 1,250,000 one-dollar shares, providing 240,000 shares to replace the 600,000 shares of Bradian owned by shareholders other than Bralorne. At the recent meeting, R. Bosustow, mine manager, reported that development on the Ida May vein at Bradian has now opened half-ounce ore across 5 ft. width for a length of 750 ft. The southeast drift is still in ore, and at the northwest end the Empire fault has been penetrated, and an orebody 7 ft. wide entered, carrying 0.16 to 0.2 oz. to the ton. It was reported that values on the 12th level of Bralorne have improved, a 90-ft. section of the King vein recently opened carrying an average of 0.413 oz. gold across a width of 2½ ft. The 5,000-ft. tunnel that will be driven to connect the two properties will serve to develop the intervening unexplored area. Ore from the Bradian will be treated at the Bralorne mill.

✦ Production during June at Cariboo Gold Quartz had a value of $40,000, and at Island Mountain $54,088, 1,545 oz. being recovered from 2,288 tons of ore. According to Douglas Lay, Resident Engineer for the district, the pyritic replacement in limestone on Island Mountain, so far as can be ascertained, is the only one in Western America carrying commercial values in gold over minable widths.

AUSTRALIA

✦ Mount Morgan, Ltd., has extended its treatment plant to handle 5,000 tons weekly. The ore reserves of this famous mine exceed 7,500,000 tons assaying 4.5 dwt. gold and 1.7 per cent copper. The ore is concentrated by flotation and the concentrates are shipped to the American Smelting & Refining Company at Tacoma, Wash., U. S. A., specially favorable freight rate and tariffs making this possible. The ratio of concentration is 23.1 and the recovery about 70 per cent. The recovery is likely to improve with the better-designed plant of larger capacity.

✦ Lake View Star, Ltd., Kalgoorlie, has placed in operation the new plant to treat the Associated tailing dump of 1,750,000 tons. The plant consists of four units with a total capacity of 40,000 tons monthly. The method used closely resembles that of the Golden Horseshoe (New), Ltd. Additional flotation cells and another diesel-electric unit now being installed will give the main mill of Lake View & Star a capacity of 50,000 tons monthly.

The British Public Continues to Emphasize Its Interest in Mining

Drilling in the Eastern Witwatersrand Reveals the Existence of a Large Gold Reef—Kenya and Tanganyika Merit Watching

(By Special Correspondence)
London

THE eagerness of the British public to participate in financing gold mining ventures has been emphasized again, an offering of 400,000 10s. shares of Rietfontein (No. 11) Gold Mines, Ltd., at a price of 22s. 6d., being oversubscribed 32 times. It was oversubscribed on the high character and dependability of its sponsors, the offering being made by Anglo American Corporation of South Africa, Central Mining & Investment Corporation, New Consolidated Gold Fields, Rand Rietfontein Estates, Selection Trust, Ltd., and the Union Corporation.

The property owned comprises 3,117 morgen (a morgen equals 2.1 acres), which has been extended to 4,408 claims by leases. It is in the eastern portion of the main Witwatersrand area, near the East Daggafontein, the Grootvlei Propriety and the Palmietkuil, and the offering companies state in their announcement: "Four boreholes, at distances of over a mile apart, put down upon the property by this company and by its predecessors in title, have shown that the sub-outcrop of the Main-Bird series lies near or beyond the company's eastern boundary, and while payable values were not disclosed, the boreholes indicate that almost the whole area of 4,408 claims is likely to be underlain by the horizon of the Main Reef Leader, between the depths of 400 ft. in the east and 3,000 ft. in the west." A vertical shaft is to be sunk forthwith, estimated depth 2,600 ft., in the northwestern part of the property.

✦ Sir Robert Williams & Company report that the power plant, workshops, and mill of the Kimingini Gold Mining Company, Ltd., in the Kakamega district of Kenya, East Africa, are practically completed. The last report received stated that a trial run of the mill might be started before the end of June, which would have been a month ahead of schedule. Development reports from this company's properties show that values disclosed down to a depth of 300 ft., and in extensive driving, have held up remarkably close to the original estimates. A rough summary of these indicates that the mining widths will average 30 to 36 in., with values of over 20 dwt. per ton.

✦ Kentan Gold Areas, Ltd., is energetically extending its development work and prospecting activities in Kenya Colony and Tanganyika Territory. It has secured an option over the 202 reef claims of the Abimbo Syndicate and also an exclusive prospecting right of 1½ square miles in Kavirondo No. 2 Area (which extends along the northwest rim of the Kakamega district). The owners of Abimbo claims have been operating a stamp battery on auriferous float. Practically no underground work has been done in either area. Kentan has also optioned the Johnson and Starnes areas, 318 reef claims, in which some high assay values have been obtained at a depth of 80 ft. It is further announced that it has optioned an area of 4 square miles in the Musoma district on the east coast of Lake Victoria. This group has been particularly fortunate in the selection of properties so far, for which the strong and efficient engineering staff maintained by Tanganyika Concessions and Zambesia Exploring companies in Africa deserves credit, and prospecting and development have in each case been conducted with commendable speed.

✦ Yellowdine developments are supplying new sensations every few days. It is announced that No. 9 shaft is being sunk in a wide orebody, the ground penetrated assaying 20 oz. of gold per ton, the ore containing arsenides and sulphides. The south drive from this shaft for a distance of 72 ft. averages 1 oz. 10 dwt. over a width of 10 ft. A new shaft is to be sunk 180 ft. west of north from No. 1 shaft to permit drawing ore from the vicinity of No. 13 shaft.

✦ The Mount Coolon Gold Mines announces that "in view of the unsatisfactory industrial situation and the present shortage of water" mining operations will be suspended. As seasonal rains cannot be expected till November or December, work probably will not be resumed for some months.

✦ Union Minière du Haut-Katanga mined 1,046,000 tons of ore last year, producing from this and certain stockpile re-treatment, 110,085 metric tons of copper. Its expenses and income were on a gold basis, the Belgian franc not being devalued till after the year had ended, and the report states that the gold price of copper averaged 4½c. a pound. The year's profit, before interest and depreciation, was nevertheless at the rate of nearly 1½c. per pound. A part of this profit came from the production of other metals, including gold, silver, tin, cobalt, platinum, palladium, and radium. Sales of cobalt were larger than ever previously and those of radium "reached a most satisfactory figure."

The gravity and flotation sections of Union Minière's concentrator were operated last year, and a new concentrator of 700 tons' daily capacity was erected at the Prince Leopold mine to treat sulphide ores. This plant was completed in May, 1935, and is in operation. Ore reserves containing approximately 250,000 tons of copper were proved last year in excess of the tonnage mined. Tin mining activities of the company were increased, 779 tons of cassiterite being produced, against 344 tons in 1933. The report makes only brief reference to the activities of the affiliated company, which is engaged in proving ores of the Northern Rhodesia type in the area south from the Katanga mines. It says prospecting continued, but that it is not yet possible for the economic value of the mineralized deposits to be determined. At the end of last year Union Minière was employing 591 Europeans and 9,100 natives, against 507 and 7,700 respectively a year earlier.

PHILIPPINE ISLANDS

✦ A modern dredge, the "Hankow," arrived in the Islands during June to be used in the mining of placer gold at the Coco Grove Placer Syndicate at Paracale, Camarines Norte. The dredge came from Hongkong, and was one of the fleet of the Netherlands Harbour Works Company. Marsman & Company, which is operating the Coco Grove property, is planning an extensive dredging campaign.

✦ Suyoc Consolidated established a new high production record in May, shipping $45,970 in bullion and concentrates. By treating the concentrates with acid, the fineness of the bullion has been raised from 300 to 600. Recoveries have been greatly improved by the use of blanket tables, $2,200 having been recovered in this way during the last week of May.

✦ Demonstration Gold, Ltd., the newest operating mine in the Baguio district, had its best month of the year in May, shipping nearly $50,000. Starting operations in December, this plant has been increasing its production each month. An increase in mill capacity is planned for the near future.

✦ Dividends for Benguet Consolidated and Balatoc Mining companies for the second quarter of 1935 amounted to $750,000 to Benguet stockholders and $700,000 to those of Balatoc. These dividends, which were paid June 30, amounted to 25 centavos a share for Benguet and 35 centavos a share for Balatoc. The first quarter dividends amounted to $1,500,000 for the two companies.

PERSONAL ITEMS

Roland McPhee has gone to La Oroya, Peru, South America.

J. A. Pike is now superintendent at the Bayonne mine, at Tye, B. C., Canada.

Sherwin F. Kelly recently lectured on geophysics before the Colorado section of the A.I.M.E.

W. B. Cramer has been appointed associate professor of ore dressing at the Colorado School of Mines.

Eugene N. Cameron has received the Samuel Franklin Emmons fellowship in geology at Columbia University.

Donald J. Doan, metallurgist, has become research physicist for the Eagle-Picher Lead Company at Joplin, Mo.

M. F. Fairlie has resigned from Mining Corporation of Canada and will practice as consulting engineer, with office in Toronto.

F. C. Dyer, of Toronto University, is conducting an investigation into the tabling of concentrates at Dufferin Mines, Nova Scotia.

Dr. F. J. Alcock, of the Geological Survey of Canada, is conducting a survey of the Lake Athabaska gold field, in northern Saskatchewan.

Stewart Campbell has returned to Boise, Idaho, after making an investigation of the gold content of the glacial gravels near Minot, N. D.

Arthur Swanson has been appointed manager of the Butte Highlands Mining Company, operating mine and mill 14 miles south of Butte, Mont.

Robert Linton is now located at 605 Edison Building, Los Angeles, Calif., and is devoting all of his time to his practice as consulting engineer.

Thomas F. Sutherland has been appointed Deputy Minister of Mines for Ontario. He had been Acting Deputy Minister of Mines for some years.

Dr. Everett P. Partridge has been appointed director of research of Hall Laboratories, at Mellon Institute of Industrial Research, University of Pittsburgh.

J. E. Hawley, processor of mineralogy at Queen's University, Kingston, Ont., has been engaged by Prospectors Airways as field geologist during the summer months.

Ott F. Heiser, manager for the Nevada-Massachusetts Company, largest of tungsten producers, has been sampling new scheelite exposures in Humboldt County, Nev.

Paul L. Schwab, president of the Gold Wave and Virac Exploration mining companies, operating in the Philippines, left the Islands in June for an extended vacation in California.

Carl D. George, formerly mill superintendent at the Jack Waite Mines, has been appointed mill superintendent for the Butte Highlands Mining Company, operaing near Butte, Mont.

Harry Oakes has resigned from the presidency of Lake Shore Mines, Ltd., and has been succeeded in that office by **Dr. W. P. St. Charles,** of Toronto, formerly treasurer of the company.

John J. Raskob, accompanied by his two sons, has visited the new Como Mines mill, the north-end mines on the Comstock Lode, and mines near Jackson, on the California Mother Lode.

Charles W. Wright sailed from New York on July 31 for Havre, on his new assignment as foreign mineral specialist of the United States Bureau of Mines, with headquarters at Rome, Italy. In addition to the foreign minerals work for the bureau, Mr. Wright will serve in an advisory capacity to United States consuls in Europe on matters relating

Charles W. Wright

to the mineral industries, in accordance with a special agreement between the Department of the Interior and the Department of State. Mr. Wright's most important work will be the study of the national mineral policies of the nations of Europe, including production-control quotas, and to get information on technical develpments and new sources of mineral supply. His address will be care of the American Consul at Rome.

H. R. Hanley, professor of metallurgy at the Missouri School of Mines, is making an extended motor trip thoughout the West, visiting metallurgical plants. He expects to return to Rolla Sept. 1.

Arthur C. Brinker left New York on Aug. 2 for Bolivia on mine-examination work. His intention was to make the journey by air between Miami, Fla., and Arequipa, Peru. He expects to return Oct. 15.

Henry C. Reel, who recently left the Climax Molybdenum Company, at Climax, Colo., is now with the mining department of Compania Minera Kildun y Annexas, S. A., Matehuala, S. L. P., Mexico.

W. Lee Heidenreich has taken charge of the operations of Opemiska Copper Company, Ltd., in northern Quebec, for Ventures, Ltd. He will divide his time between the camp and his office in Toronto.

Paul M. Sorensen, who was formerly connected with mining operations in the Southwestern United States, is superintendent and manager of the Hirst-Chichagof Mining Company at Kimshan Cove, Alaska.

R. M. Schade, located in Indo-China for two years with the Société de Indo-Chinoise d'Exploitation Minerois et Agricolas, has recently joined the staff of the Balatoc Mining Company in the Philippines as mill shift boss.

L. E. Shaffer is developing the Bluebell placer property in the Tarryall district of Park County, Colo. The property contains 230 acres of virgin placer ground. His two brothers are associated with him in the enterprise.

Merle H. Guise, who developed a small placer gold mine in British Guiana and who has been examining and developing Arizona and California placer and lode properties during recent months, has returned to his headquarters at Fairbanks, Alaska.

Wesley P. Goss, formerly chief efficiency engineer and assistant superintendent at the United Verde mine, Jerome, Ariz., has accepted the position of assistant superintendent at the Park City Consolidated Mines company at Park City, Utah.

Birger H. Strom, formerly metallurgist with Anaconda at Great Falls, Mont., and more recently assistant editor of *Engineering and Mining Journal,* has accepted a position with the Fisher Scientific Company, 709 Forbes St., Pittsburgh, Pa., handling publicity.

H. Hardy Smith, after being associated with South African mining groups in a metallurgical capacity for a number of years, has joined the staff of Charles Ruwolt, Pty., Ltd., manufacturers of mining and milling equipment at Melbourne, Australia, as metallurgical engineer.

J. L. White is now superintendent of the Anaconda Mining & Milling Company. This company is now installing a 600-hp. diesel-electric plant in preparation for unwatering the famous old Clover Leaf mine at Roubaix. S. D. This mine was flooded in 1905 while operating on a 200-ton per day basis of gold ore. The company has no connection with the Anaconda Copper Mining Company.

Luther W. Lennox, formerly of the staff of The Merrill Company, engineers, San Francisco, arrived in the Philippine Islands in June to become the general superintendent of the Benguet Consolidated Mining Company. **D. W. Butner,** former general superintendent, has been transferred to a similar position at the Balatoc Mining Company.

J. B. Tyrrell, president and managing director of the Kirkland Lake Gold Mining Company, Ltd., was recently the host, at the York Club, Toronto, to thirteen out of the fourteen survivors of the Class of 1880, University of Toronto. Among those present, also, was **Prof. Alfred Baker,** the mathematics teacher of the class. Professor Baker is 88. The class dined with Mr. Tyrrell five years ago and will dine with him again in 1940.

J. W. Still, formerly mine superintendent for Bagdad Copper, Yavapai County, Ariz., has sailed for the Philippines.

Waina A. Kaattari has joined the metallurgical division of The Dorr Company, Inc., with headquarters in Denver.

Joseph H. Portugal is examining gold and silver properties in Oregon, Nevada, and Montana for R. Potter Campbell, Inc., of New York.

William Russell, of Dorr Oliver, Ltd., London, England, has been elected a member of the council of the Institution of Mining and Metallurgy.

Charles F. Jackson has been designated as acting head of the Mining Division of the United States Bureau of Mines in place of C. W. Wright.

Max Kraut, metallurgical engineer, Pau-American Engineering Corporation, Ltd., has returned to San Francisco from a business trip to Nevada.

A. John Eveland, field engineer and geologist with R. Potter Campbell, Inc., of New York, is in Mexico examining mining properties for his company.

J. P. Schemmell, formerly superintendent of the Dunwoody mine for the Pickands Mather Company, has been made superintendent of the Albany mine at Hibbing, Minn.

Fred G. Farish has been appointed chief engineer of R. Potter Campbell, Inc., New York City, which company is interested in the acquisition and operation of gold and silver properties.

Alberto Terrones Benitez is in the State of Durango, Mexico, to examine important gold zones of the Otaez mining district and also to investigate the antimony zones of the Cuencamé district.

R. G. Walker, vice-president and general sales manager of Oliver United Filters, Inc., New York, Chicago, and San Francisco, recently returned from an extended business trip through the mining districts of northern and eastern Ontario.

John Van Nostrand Dorr, president of The Dorr Company, Inc., has returned from a trip to the Pacific Coast, during which he revisited the Black Hills of South Dakota, scene of his early experience in the mining and metallurgical fields.

Raymond Crighton, production manager of The Dorr Company's organization in Japan, returned to the United States last month after 4½ years in the Orient, en route to Scotland for a month's vacation. He will return to Tokyo, via the United States, in September.

Arthur D. Camp joined The Dorr Company, Inc., on July 5, as librarian in charge of the data department. Mr. Camp, a Cornell graduate in chemistry and engineering, is a member of the I.A.Ch.E. and the A.C.S. and was formerly associated with the Thomas & Hochwalt Laboratories of Dayton, Ohio.

R. M. Macaulay, vice-president of Quebec Gold Mining Corporation, has been appointed general manager of Pamour Porcupine Mines, Ltd., in the Porcupine district, northern Ontario. Mr. Macaulay will remain vice-president of Quebec Gold, but will devote all his time to Pamour and become resident at the mine.

C. W. Newton, general manager of the Callahan Zinc-Lead Company, at Interstate, Idaho, resigned his position as manager, director, and secretary-treasurer to accept a position with other interests. He is continuing to carry on the business of the company until the president, **Donald A. Callahan,** returns from New York.

Charles C. Samuels, recent manager of the Sunshine Mining Company, operating in Shoshone County, Idaho, has become consulting engineer for the Penman Mines Corporation in the central Idaho gold belt, according to a Seattle report. Mr. Samuels will continue as president and general manager of the Gold Hill Operating company on Azurite Mountain, Washington.

J. P. Hodgson retired as manager of the Bisbee mines of Phelps Dodge effective Aug. 1. He has been active in mining for more than 50 years and has been associated with Phelps Dodge for more than 20 years. He will retain association with the company in a consulting capacity. **I. H. Barkdoll,** for some years in charge of the Old Dominion mine, at Globe, Ariz., will assume charge at Bisbee as general superintendent.

Ivan E. Goodner has returned to Durango, Colo., to assume charge of the reopening of the old Idaho mine, final title to which was recently acquired by La Plata Mountains Gold Mines, Inc., and will remain here until the property is in full production. **Lewis Sanders,** consulting engineer, 381 Broadway, New York City, is spending a month with him, sampling the property and directing the study and plans for a 50-ton flotation-cyaniding plant.

Grover C. Dillman, Michigan State Welfare Director and former State Highway Commissioner, has been unanimously elected president of the Michigan College of Mining and Technology at Houghton by the board of control of the institution. He will succeed Dr. William O. Hotchkiss, who resigned to become president, Sept. 1, of the Rensselaer Institute of Technology at Troy, N. Y. Mr. Dillman is a graduate of the Michigan State College. He is a past president of the Michigan Engineering Society.

Charles Camsell, Deputy Minister of Mines, Ottawa, was recently designated by His Majesty King George V to be a Companion of the Order of St. Michael and St. George. He is now on a tour by air of northern British Columbia and the Yukon, the scene of his youthful adventures in the Klondike gold rush. His party will map from the area an unexplored tract of 25,000 square miles astride the Yukon-Northwest Territories boundary. He will visit a number of the Canadian Geological Survey field parties in the course of a 10,000-mile tour.

O. P. Hood, on the authority of an order by President Roosevelt, has been exempted from the retirement provision of the Civil Service law. Had the order not been forthcoming Dr. Hood would have had to retire at the close of the fiscal year, having reached the age of 70. His service with the Bureau of Mines began in 1911 as chief mechanical engineer of the Bureau. He became chief of the technologic branch of the Bureau with its creation in 1927. Prior to his service in Washington he served thirteen years as professor of mechanical and electrical engineering at the Michigan College of Mines. He was a member of the class of 1885 at Rose Polytechnic Institute.

OBITUARY

Charles Renwick, mining engineer, of Richmond, Calif., died on June 15, at Cholula, Puebla, Mexico.

James McEvoy, Canadian geologist and mining engineer, died at Corbin, B. C., on July 19, at the age of 73.

Benjamin S. Woodward, prominent in the mining circles of Utah and Nevada, died recently at Salt Lake City. He was 46 years old.

David B. Gemmill, president, Prince Consolidated Mining Company, long identified with mining interests in the Southwest, died recently at Altadena, Calif. He was 55 years old.

Anson Hubert Smith, mining man, newspaper man, editor of the *Mohone County Miner* for 53 years, for many years a leading citizen in the development of the Kingman section of Arizona, and designated by former President Hoover as the "Father of Boulder Dam," died in Kingman on June 19.

Louis Mariano Nesbitt, a British mining engineer, was killed in an airplane accident in Italian Switzerland on July 20. He had recently made a hazardous journey across Ethiopia and written a book describing life in the Ethiopian lowlands. Twelve other passengers and operators of the plane were killed in the crash.

R. W. Brock, dean of the faculty of practical science of the University of British Columbia and well-known geologist, was killed recently in an airplane crash 50 miles north of Vancouver, along with the pilot, William McCluskey. Mrs. Brock and David Sloan, who were also in the plane, bound for the Pioneer mine, at Bridge River, were injured.

Charles L. Cantley was drowned on July 14 while bathing at Scarboro Beach, Maine. A Nova Scotian by birth, aged 51, he was employed as metallurgist by several corporations in the United States and Canada and since 1933 had been manager, and latterly president, of Nichols Engineering & Research Corporation of Canada, with headquarters in Montreal.

Glenn R. Bothwell, for 40 years an outstanding figure in Utah and Idaho mining, agricultural and industrial enterprises, died at his Salt Lake home July 5 of a heart attack. He was president of the Sacramento Gold Mining and Milling Company in the boom days of Mercur, and later became interested in mining at Bingham. During the last two years, Mr. Bothwell was engaged in the construction of a mill on the Geyser Marion property at Mercur for the treatment of gold ores.

Joseph Cole and **H. L. Roscoe,** engineers in the employ of the Explosives Division, Canadian Industries, Ltd.,

were killed on July 25 at Waverley, near Halifax, N. S., under unusual circumstances. They were examining the former site of a dynamite plant, unused for twenty years, with a view to removing any nitroglycerine that might have accumulated in the soil by spillage and thereby have become a menace. The manner in which they met death is not known. Mr. Cole, aged 58, lived at Rajand, near Montreal, and Mr. Roscoe was a resident of Halifax.

LETTERS

Design of Mine Roofs And Supports

The Editor:

Two articles in your February and April issues on the mechanics of mining, by Bucky and Toering, contain much valuable information. I would appreciate it very much if you would give the authors space to answer a few questions that occur to me.

Inasmuch as the models show a continuous deflection from the supports to the center, does this prove there is no point of inflection in a mine roof beween the pillar and the center of the span?

Is there not an arching effect in mine roofs?

Where does the maximum bending moment occur—that is, in the center of the span as a simple beam; over the pillar as a pipe line or continuous beam; at the junction (approximately) of roof and pillar as determined by the method outlined by Paswell in his book on Retaining Walls when in regard to subsurface structures he uses the method for indeterminate structures; or does it exist at some other place?

M. M. Butler.

Casper, Wyo.

The Editor:

I appreciate Mr. Butler's interest in my research work and will endeavor to answer his questions.

The points of inflection and maximum bending moment for uniformly loaded beams are determined by the amount of restraint. In mining work our restraint varies, as we have ample evidence of surface rises over the solid pillar and ahead of the workings. The methods being used here to determine the effects of partial restraint are by means of models and the centrifugal method of testing. The models may be scalar and of the same material as the prototype or of Bakelite and combined with the photo-elastic apparatus. The combined centrifugal and photo-elastic apparatus will definitely show where the maximum bending moment occurs.

There is an arching effect in some mine roofs, not in all of them. This effect, while talked about a great deal, leaves much to be ascertained. In T. P. 425 (A.I.M.E.) you will find something along this line that may interest you.

The point of view expressed by my articles, while generally accepted in structural work, is new in mining, and, as a matter of fact, is not fully accepted. The research work has been going on since 1929 and is supported by the Engineering Foundation.

Philip B. Bucky,
Associate Professor of Mining
Columbia University,
New York City, N. Y.

Photo-electric Cell Controls Hoist

The Editor:

In the March issue of *E.&M.J.* there is an article by Gail Martin on the use of a photo-electric cell on hoist control at the United States Smelting, Refining & Mining property at Bingham, Utah.

It may be of interest to describe an installation of a signal device which was the first use of a photo-electric cell on a mine hoisting installation.

At No. 5 shaft of the Montreal mine, at Montreal, Wis., operated by Oglebay, Norton & Co., a new high-speed hoisting equipment was installed in 1929-30 to hoist from the 33 to 28 level intermittently. It was desirable to have a signal device which would warn the hoist operator exactly when the skip started to enter the dump curve. This can be done by a mechanical device operated by contact with the skip, but such switches are difficult to maintain and are not reliable.

About this time the photo-electric cell was used on some industrial control experiments. I decided to install such a device to signal the skip position to the hoist operator. The photo-electric cell was assembled in an iron box with an amplifier tube and a rectifier to give sufficient energy to operate a small relay switch. To prevent injury to the tubes, as the headframe was subject to considerable vibration, the tube case was set on a sponge rubber mat. A pair of wires energized at 110 volts connected the relay with the switchboard bull's-eye lamp placed in front of the hoist operator at 800 ft. distance. The relay was connected so that when the photo-electric cell was not energized the lamp would light.

To furnish the light beam for signal purposes, a lamp was placed in a box with a hole arranged so that a ray of light passed across the shaft and entered the hole in the tube box, thus energizing the photo-electric cell. The light ray was to be interrupted by the skip just as it started to enter the dumping curve. After the skip moved into a horizontal position the light beam was reestablished and the signal lamp in the engine room was extinguished. On leaving the dump position the skip again established the engine-room signal. The hoist operator was therefore positive of the exact position of the skip in regard to its dumping position. The expected trouble from tubes did not materialize and the device has been successful. Both tubes and amplifier equipment were furnished by the Westinghouse Electric & Manufacturing Company. W. M. Hoen.

Glavtswetmet Vetoshmll per. 15
Room 406. Moscow, U.S.S.R.

An article published in *E.&M.J.* on Aug. 10, 1931, contained brief reference to the use of the photo-electric cell on the headframe of Montreal No. 5 shaft.—Editor.

Notes on Blasting With Safety Primers

The Editor:

In the interesting and valuable article by Thomas Soule on "Blasting With Safety Primers" in tunnels in the Metropolitan Water District of Southern California, which appears in the May issue of *Engineering and Mining Journal* (p. 235), it is stated:

"The Rand district of South Africa was the first to use the safety primer so far as known. As the use of this primer proved successful from a safety standpoint with fuse blasting in South Africa, an Arizona copper mine raised the question as to whether or not the safety primer could be used for electric blasting. To determine this the engineers at the property conducted some experiments about two years ago. . . . So impressed were they that they adopted it as standard practice."

While visiting mining districts in Great Britain in 1931, I saw this type of wood sheath for electric detonators, similar to that now used by the Metropolitan Water District, and brought back with me to this country and distributed some samples of what the British users called "dummy primers." They had then (1931) been in use for several years at collieries in the Midland district with the sanction of the British Mines Department, and 5,000 shots had been fired without failure in blasting in coal and in rock.

Those interested in the subject will find a very complete description with illustrations of the primer used in a paper entitled "The Use of Dummy Primers in Shot-firing," by R. G. Richardson, *Transactions* Mining Engineers (Great Britain), Vol. 80 (Feb., 1931), p. 358, followed by an extensive discussion.

A. M. Henshaw stated that when he was a student at a mining school 50 years previous, Captain Brown, later Sir Francis Brown, an artillery officer, who Mr. Henshaw stated "first introduced the firing of blasting charge in mining by electricity," gave demonstrations of firing electric detonators placed "in wood bobbins almost identical" with those that have been described by Mr. Richardson.

Dr. Payman, of the Safety in Mines Research Board, appeared doubtful about the use in gassy mines of dummies made of wood, because of their inflammable characteristics,, and suggested making them of molded clay. However, no ignitions of firedamp have been reported, and most of those discussing the paper were highly favorable to the use of the wood dummy primers.

The paper mentioned in the foregoing, and the discussion, included consideration of the best position in the charge of explosive for the placing of the primer as regard efficiency and safety. The consensus of opinion was that it should be at the outer end of the charge rather than in the middle or back end of the charge. George S. Rice,
Chief Mining Engineer,
United States Bureau of Mines
Washington, D. C.

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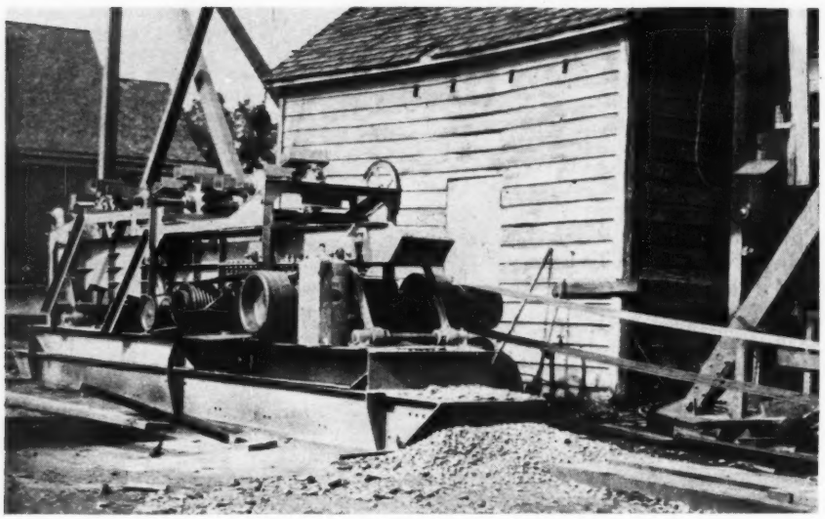
EQUIPMENT NEWS



A Placer Machine Which Is Easily Moved And Requires Little Water

"Desert Sluice" With a Capacity of 15 to 25 Cu.Yd. per Hour

• Newest among portable concentrators for recovering coarse and fine gold from gravels to be introduced to the mining industry is the so-called "desert sluice," invented by G. W. Rathjens, chief engineer, United States Smelting, Refining & Mining Company, and handled by the National Equipment Company, of Salt Lake City, Utah. Apart from an entirely new operating principle, several novel features have been embodied in the design of the new machine, which is compact and built of steel. Capacity of a 15-in. unit is from 15 to 25 cu.yd. per hour, depending upon the nature of the material treated, and the total floor space required is an area measuring but 3x20 ft. Power and water consumption are exceedingly low, 10 hp. being sufficient to drive a 15-in., 6-riffle pan machine, and less than 20 hp. are required to start it. Water consumption is less than 1 per cent of that ordinarily used.

As will be seen in the accompanying cut, the concentrator consists essentially of a steel base, a sluice containing six riffle pans each 15 in. wide and 18 in. long, the drive mechanism, and sundry accessories. The riffles proper are of special design, and, because of the motion they are subject to, never pack. Tests conducted with gravels containing known quantities of placer gold resulted in recoveries approaching 100 per cent. A 15-in. machine recently shipped to Barber Canyon, Nevada, is reported to give a most satisfactory performance as to recovery and yardage.

Protection Against Shocks Feature of Pin Coupling

• The pin couplings developed by Smith & Serrill, of 24A Washington Place, Newark, N. J., are said to consist of a bundle of steel laminations which are copper coated to resist rust and held in a slotted keeper by hardened steel cross pins welded in place. These pins are said to be held in place in one flange by a spring retaining ring, and in the larger sizes radial bolts are used. On the other, flange hardened steel bushings are used having rectangular broached holes to receive the sliding ends of the pin couplings which are locked in place. This facilitates easy removal after several years of service. It is said that the load pressure between the bronze bearings strips and the sides of the broached bushings is separated from the pressure due to centrifugal force, as the laminated springs contact with the upper inside surface of the bushing as well as with the sides of the bushing. These pin couplings are listed in 21 regular sizes rated up to 4,200 hp. per 100 r.p.m. and for shafts up to 13¼ in. diameter.

An Interchangeable Breaker And Sheeting Driver

• A development in dual application of one tool is the Worthington No. 10 Master Breaker, which is convertible into a useful sheet piling driver. It is said to be most useful for the heaviest class of concrete breaking, general demolition work, crushed rock tamping, loosening hardpan, and removing slag in a blast furnace. In its convertible form it is for driving sheet piling. The net weight of the breaker is 82 lb.; length over all without tools, 29 in. The net weight of the sheeting driver is 120¼ lb.; length over all, 28¾ in.

Large-Capacity Crushers For Laboratory Service

• A line of so-called "Rolling Ring" and swing-hammer crushers and grinders for laboratory service which are designed for large capacity at low cost and for minimum space requirements is announced by American Pulverizer Company, St. Louis, Mo. Construction features outlined by the company include: compact and simple design; all parts of housing machined for dust-tight fit; interchangeability of parts; split frame for quick accessibility and cleaning, thus preventing contamination of the product and permitting quick changing of screen plates or cage bars; rotor or cylinder consisting of a heavy main shaft of alloy steel, cast-steel end disks and manganese steel rings or hammers; main shaft rotating in SKF ball bearings mounted in dust-tight, self-aligning pillow blocks; screen plate sliding in grooves in the lower housing; grinding practically all done by the breaker and grinding plates in the front of the chamber, which can be quickly and easily renewed; round back of upper frame protected by renewable liner. These mills are available in 9x9-in. and 15x9-in. sizes.

Automatic Adjustable Orifice

• An adjustable orifice which automatically shifts its position in accordance with major changes in rate of flow is a new development of the Barclay Meter Company, Cleveland, Ohio. This automatic orifice is similar in appearance to a hydraulically operated gate valve. The gate of the automatic orifice, however, is a sharp edge segment, coefficients for which are determined. Its position varies the size of the orifice opening through which the fluid measured must pass. Movable stops limit the stroke of the hydraulic piston so that the orifice segment rests in either one or two definite positions. The piston which positions the orifice is actuated by a solenoid-operated valve, which in turn is commanded by contacts made in the recording meter. Through the solenoid valve, hydraulic pressure is admitted to either end of the cylinder and the other end is opened to drain. When the differential pressure across the adjustable orifice reaches a predetermined minimum or maximum, a contactor within the meter casing energizes the solenoid valve, and this is said to automatically change the orifice opening to correspond with a new capacity. Simultaneously with this change, the integrator drive is shifted to a second

motor, so that it continues to measure accurately the total flow, regardless of the orifice position. In addition to changing the orifice position and integrator speed, the contactor also energizes a small solenoid which operates an auxiliary recording pen to show the proper multiplying factor to be applied to the corresponding flow record on the chart.

New Type of Air Hose Built Like a Tire

• The Mechanical Goods Division of the United States Rubber Products, Inc., announces a new type of hose for pneumatic and air drills which is built like a tire. The hose is said to consist of "tire-like" cords laid in tough rubber cushions isolated from adjacent plies to prevent rubbing or shearing. It is claimed this type of hose can withstand any amount of pulsation, sudden expansion under pressure, and constant flexing in use. Also, that the specially compounded brown rubber cover will stand unusual abuse, shows remarkable resistance to external blows, bruises, and abrasions, and will not peel when cut or gouged.

Positive Line Prints By Dry Process

• A dry-developing process that, in one operation, will make positive line prints, with a background which takes pencil notations, has been introduced by Ozalid Corporation, 354 Fifth Ave., New York City. Special sensitized paper—available in types giving blue, maroon, black, or brown line; also single and double sensitized tracing cloth for making prints equivalent to tracings, the double sensitized cloth developing on both sides—is exposed in any standard printing machine and is then passed through ammonia vapor in the Ozalid developing machine. Features listed by the company include: elimination of shrinkage and warping, giving true-to-scale prints without affecting the texture or strength of the paper, and adaptability to the use of less expensive printing paper, as no washing or drying is involved. The developing machine is 62½ in. high, 51 in. long, and 23 in. deep, and is supplied for both 110 and 220 volts, alternating or direct current.

Automatic-Reversing Puller-Hoist

• Combining the functions of a pulling jack and a chain hoist of 1½ tons' capacity, the so-called "Anchor" automatic-reversing puller-hoist has been introduced by Edelblute Manufacturing Company, Reynoldsville, Pa. To operate it, the device is securely anchored and the 15-ft. load chain attached to the load, or vice versa, after which the chain is taken up a notch at a time by working the handle. The equipment, it is claimed, can be used in any position as well as in close quarters. Pulling or hoisting speeds range from 2 to 4 ft. per minute, depending on the load. Total weight, including the chain, is 45 lb. Applications, besides the usual ones, include: tightening trolley and power lines; reclaiming timbers; retracking cars; pulling conveyors, belts, chains, and ropes for splicing; shifting track.

Extinguishing Fires By Dry Compound

• For purposes of fire control, a first-aid fire-extinguishing appliance known as the Garfire gun has been introduced by Garrison Engineering Corporation, Waukesha, Wis. The new device consists of a pump gun and a fire-extinguishing-compound projector, both substantially made, with an outside shell of brass. Operation involves turning the pump handle to unlock it for pumping and pushing aside the spring clamp which normally keeps the nozzle closed. By the pump action a cloud of dry compound is shot at the flames, killing them instantly at contact and insulating the burning objects. The extinguisher is said to do no damage to anything except fire and to cost little to maintain.

Medium Pressure Generators Of Acetylene

• Three sizes of acetylene generators, containing 150-lb., 300-lb., and 500-lb. carbide capacity, with acetylene generating capacity from 300 to 1,000 cu.ft. per hour, have been announced by the Linde Air Products Company, 30 East 42d St., New York City. These generators are for stationary service and are designated as Oxweld Type MP-5.

Two-Conductor Control For Grab Buckets

• Improved motor-driven grab buckets ranging from ½ to 3 cu.yd. in capacity have been placed on the market by the Erie Steel Construction Company, Erie, Pa. As each bucket carries its own motor, it can be attached to cranes, monorail hoists, or other hoisting equipment operated by electric power. Either alternating or direct current may be used, and a Westinghouse crane motor, brake, and gearing are mounted in the bucket. Special Westinghouse direct-current control makes possible the use of only two conductors between the control cab and the bucket, according to the manufacturer.

Industrial Notes

• International Nickel Company has announced the addition of O. W. McMullan to the research staff and Harold L. Geiger to the field staff of the department of development and research, which is under the management of A. J. Wadhams. Mr. McMullan was formerly chief metallurgist for the Timken-Detroit Axle Company. Mr. Geiger was chief metallurgist for the Wisconsin Steel Company.

• McKinnon-Columbus Chain, Ltd., of St. Catharines, Ontario, has sent a group of 25 executives and key men to South Africa to open and operate a new plant near Johannesburg for making chain specialties of all kinds, particularly industrial chain and chain hoists. The group is under the direction of F. E. Stahl.

• A. R. Wilfley & Sons, Inc., are now represented in eastern Canada by Canadian Vickers, Ltd., at Montreal, and in western Canada by Manitoba Bridge & Iron Works, Ltd., at Winnipeg.

BULLETINS

Sauerman Long Range Machines. Sauerman Bros., Inc., 484 South Clinton St., Chicago. Catalog No. 17, description, illustrations, capacity tables, and other operating data pertaining to Sauerman Drag Scrapers, Slackline cableways, Slackline scrapers, Tautline cableways. Contains 145 illustrations and 56 pages.

Wilfley Concentrating Tables. Mine & Smelter Supply Co., Denver, Colo. Bulletin No. 64A. 12 Pp.

Guide for Selecting V-Belt Drives. Gates Rubber Co., Denver, Colo. Tables, design, and price lists of V-belt drives. Pp. 64.

Air-Operated Combustion Control. Bulletin No. 102, Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio.

Automatic Starters. Allen Bradley Co., Milwaukee, Wis. Bulletin 709. Solenoid type starters. Pp. 5.

Barriers to Industrial Waste. Johns-Manville Co., 22 East 40th St., New York City. Pocket booklet of insulating materials. Pp. 64.

Vertical Sewage and Drainage Pumps. Worthington Pump & Machinery Corp., Harrison, N. J. Bulletin W-316-B3. Wet-pit operation, automatic high-water alarms. Pp. 8.

Air Compressor Units. Worthington Pump & Machinery Corp., Harrison, N. J. Bulletin L-620-B5A, Types VS and VA-2. Pp. 4.

Horizontal Duplex Piston Pumps. Worthington Pump & Machinery Corp., Harrison, N. J. Type PC for handling liquids at pressures up to 800 lb. per square inch. W-103-B1. Pp. 4.

Surface Condensers. Worthington Pump & Machinery Corp., Harrison, N. J. Folded tube layer arrangement. Bulletin W-200-B2a. Pp. 4.

Sump Pump No. 5. Worthington Pump & Machinery Corp., Harrison, N. J. W-450-B22.

Bantam-Weight Excavator. Harnischfeger Corp., Milwaukee, Wis. Bulletin 100-A. Interchangeable dragline, shovel, or clamshell on auto truck or caterpillar tractors. Pp. 16.

Deep-Well Turbine Pump. Worthington Pump & Machinery Corp., Harrison, N. J. Bulletin W-450-B17A. Pp. 7.

Wire Rope. Macwhyte Co., Kenosha, Wis. Helpful information in selecting wire rope. Pp. 4.

Vertical Centrifugal Pumps. Single-stage volute. Worthington Pump & Machinery Corp., Harrison, N. J. For pumping sludge, and liquids containing solids in suspension. Bulletin W-317-B4.

Air-Lift Pumping Systems. Worthington Pump & Machinery Corp., Harrison, N. J. Bulletin L-800-B1. Pp. 3.

Power-Transmission Equipment. The Medart Co., St. Louis, Mo. Catalog No. 56T. Pp. 144.

Diaphragm Pump. T. Shriver & Co., Harrison, N. J. Bulletins 101 and 102. Pp. 3 in each bulletin.

Air Operated Combustion Control. Bailey Meter Co., Cleveland, Ohio. Bulletin No. 102. Pp. 31.

Semi-Automatic Engine Lathe. Monarch Machine Tool Co., Sidney, Ohio. Catalog. Pp. 13.

Single and Twin Cylinder Horizontal Diesel Engines. The Cooper-Bessemer Corp., Grove City, Pa. Diesel engines of 25-110 b.h.p., specifically developed for stationary service for the smaller power uses. Pp. 10.

Feeders. Hardinge Co., York, Pa. Bulletin No. 33-C. A feeder which controls feed from bin by weight rather than volume.

Rock Bit Grinder. Mine & Smelter Supply Co., Denver, Colo. Four types of detachable rock-bit resharpening machines. Pp. 4.

SUMMARY OF

MONTHLY COMMENT . . . DAILY AND AVERAGE MONTHLY

DEMAND for major non-ferrous metals was quite active during July, contrary to expectations, and the undertone showed marked improvement. Prices, with the exception of silver, were firmer. Domestic copper was quotably unchanged, but the foreign market was moderately higher. Lead advanced 15 points, and Prime Western zinc moved up 10 points for the month. Tin was strong on scanty offerings of spot material. Silver was subjected to heavy selling by speculators abroad, resulting in a decline of 2c. in the open-market quotation. The fall in silver was arrested when the Treasury purchased large quantities.

Uncertainty over the international copper program was removed when, after a meeting of the group in London, the following statement was issued.

"Last March an accord was reached for the restriction of production in the principal copper countries other than the United States. At this time it was agreed that meetings would be held from time to time to examine the situation. In the course of the present meeting the March accord was confirmed in its entirety. Various questions relative to the industrial use of copper outside the United States were discussed, and unanimous agreement was reached on all points."

Domestic shipments of copper, lead, and zinc during the first half of the current year, by months, in short tons, were as follows:

	Copper	Lead	Zinc
January	38,250	33,695	35,538
February	39,750	32,518	34,870
March	34,250	28,973	41,137
April	42,500	40,922	38,457
May	39,000	32,341	35,629
June	36,000	26,978	29,393
Totals	229,750	195,427	215,024
Monthly averages	38,291	32,571	35,837

Shipments of copper in the domestic market in the first half of 1935 were about 7 per cent smaller than in the same period last year. The movement of copper last year was accelerated by the rising price-trend under NRA control. Shipments of lead increased 9.5 per cent, compared with last year, with the movement of zinc to consumers up 13.7 per cent over 1934.

Sales of copper in the domestic market during July totaled 73,500 tons, according to a record of transactions reported by producers. Zinc business was quite active in the last week of the month, when about 18,000 tons were disposed of, chiefly to galvanizers. Lead experienced a fairly active period early in July.

The *E.&M.J.* weighted index of non-ferrous metal prices declined from 79.57 in June to 76.33 in July, on lower averages for copper and silver.

United States Market

1935 July	Electrolytic Copper Domestic (a)	Electrolytic Copper Export (b)	Straits Tin New York	Lead New York	Lead St. Louis	Zinc St. Louis
1	7.775	7.000	51.750	4.00	3.85	4.30
2	7.775	7.050	51.850	4.00	3.85	4.30
3	7.775	7.125	51.950	4.00	3.85	4.30
4	Holiday	7.150	Holiday			
5	7.775	7.150	51.950	4.05	3.90	4.30
6	7.775	7.125	52.100	4.05	3.90	4.30
8	7.775	7.125	52.200	4.10	3.95	4.30
9	7.775	7.150	52.150	4.15	4.00	4.30
10	7.775	7.175	52.200	4.15	4.00	4.30
11	7.775	7.300	52.175	4.15	4.00	4.30
12	7.775	7.375	52.050	4.15	4.00	4.30
13	7.775	7.400	52.150	4.15	4.00	4.30
15	7.775	7.525	52.250	4.15	4.00	4.30
16	7.775	7.650	52.350	4.15	4.00	4.30
17	7.775	7.525	52.500	4.15	4.00	4.30
18	7.775	7.525	52.450	4.15	4.00	4.30
19	7.775	7.525	52.525	4.15	4.00	4.30
20	7.775	7.500	52.525	4.15	4.00	4.30
22	7.775	7.525	52.750	4.15	4.00	4.30
23	7.775	7.550	52.450	4.15	4.00	4.30
24	7.775	7.525	52.500	4.15	4.00	4.30@4.40
25	7.775	7.450	52.000	4.15	4.00	4.40
26	7.775	7.400	52.300	4.15	4.00	4.40
27	7.775	7.400	52.500	4.15	4.00	4.40
29	7.775	7.400	52.700	4.15	4.00	4.40
30	7.775	7.400	52.700	4.15	4.00	4.40
31	7.775	7.425	52.700	4.15	4.00	4.40
Av. for month	7.775	7.350	52.297	4.123	3.973	4.325
Averages for Week						
3	7.775	7.013	51.800	4.00	3.85	4.300
10	7.775	7.146	52.120	4.10	3.95	4.300
17	7.775	7.463	52.246	4.15	4.00	4.300
24	7.775	7.525	52.533	4.15	4.00	4.308
31	7.775	7.413	52.483	4.15	4.00	4.400
Calendar Week Averages						
6	7.775	7.100	51.920	4.020	3.870	4.300
13	7.775	7.254	52.154	4.142	3.992	4.300
20	7.775	7.542	52.433	4.150	4.000	4.300
27	7.775	7.475	52.417	4.150	4.000	4.358

Silver, Gold, and Sterling Exchange New York and London

1935 July	Sterling Exchange "Checks"	Sterling Exchange "90-day Demand"	Silver (c) New York	Silver London	Gold London	Gold (d) United States
1	4.94000	4.92250	69.750	31.2500	141s 4½d	$35.00
2	4.93750	4.92000	69.500	31.0000	141s 7 d	35.00
3	4.93750	4.92000	69.375	31.0000	141s 6 d	35.00
4	Holiday	Holiday		31.0000	140s 11 d	Holiday
5	4.94000	4.92250	69.000	31.0000	140s 11 d	35.00
6	4.95625	4.93875	68.750	30.6875	141s	35.00
8	4.96000	4.94750	68.250	30.4375	140s 9 d	35.00
9	4.98250	4.96500	68.125	30.3500	140s 7 d	35.00
10	4.95750	4.93750	68.750	31.1250	140s 11 d	35.00
11	4.95750	4.93875	69.375	31.3125	140s 8 d	35.00
12	4.95000	4.93125	68.750	31.1250	140s 11 d	35.00
13	4.95500	4.93625	67.750	30.3125	140s 11 d	35.00
15	4.96000	4.94125	67.750	30.1875	140s 9½d	35.00
16	4.95750	4.94000	67.750	30.1875	140s 11½d	35.00
17	4.96000	4.94250	67.750	30.1875	141s ½d	35.00
18	4.95375	4.93625	67.750	30.1875	140s 11½d	35.00
19	4.95000	4.93250	67.750	30.1875	141s ½d	35.00
20	4.96250	4.94500	67.750	30.1875	141s ½d	35.00
22	4.96000	4.94250	67.750	30.1875	140s 8½d	35.00
23	4.96000	4.94250	67.750	30.1875	140s 5 d	35.00
24	4.95250	4.93625	67.750	30.1875	140s 6 d	35.00
25	4.95750	4.94000	67.750	30.1875	140s 9 d	35.00
26	4.96250	4.94500	67.750	30.1875	140s 6½d	35.00
27	4.96250	4.94500	67.750	30.3750	140s 5½d	35.00
29	4.95750	4.94125	67.750	30.1875	140s 7 d	35.00
30	4.96000	4.94500	67.750	30.1875	140s 5 d	35.00
31	4.95500	4.93875	67.750	30.1875	140s 8 d	35.00
Av. for month	4.95558	.....	68.216	30.500	.....	35.00
Averages for Week						
3	4.93958	.....	69.563	.....	.....	.....
10	4.95925	.....	68.575	.....	.....	.....
17	4.95667	.....	68.188	.....	.....	.....
24	4.95646	.....	67.750	.....	.....	.....
31	4.95917	.....	67.750	.....	.....	.....

Calendar week averages: New York Silver July 6th, 69.275; 13th, 68.500; 20th, 67.750; 27th, 67.750.

The above quotations for major non-ferrous metals are our appraisal of the important United States markets, based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices are in cents per pound.

(a) Net prices at refineries on Atlantic seaboard. To arrive at the delivered New England basis, add 0.225c. per pound, the average differential for freight and interest charges.

(b) Export prices are net at refineries on the Atlantic seaboard and include sales of domestic copper in the foreign market. Most sales in the foreign market are made on the basis of c.i.f. usual ports of destination—Hamburg, Havre, and Liverpool. The c.i.f. basis commands a premium of 0.300c. per pound above our refinery quotation.

Copper, lead and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

Quotations for copper are for the ordinary forms of wirebars and ingot bars; cathodes discount of 0.125c.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York commands a premium over the St. Louis basis equal to the freight differential. Contract prices for High-Grade zinc delivered in the East and Middle West in nearly all instances command a premium of 1c. per pound over the current market for Prime Western but not less than the *E. & M. J.* average for Prime Western for the previous month.

Quotations for lead reflect prices obtained for common lead and do not include grades on which a premium is asked.

(c) Silver other than newly mined domestic. Under Executive order issued April 24, 1935, the U. S. Government's price on newly mined domestic silver was established at 77.57.

(d) U. S. Treasury's gold price. Actual payment by the United States Treasury for gold in imported ore or concentrate is at 99.75 per cent of the price quoted by the Treasury, which at present is equal to $34.9125 per ounce.

THE MARKETS

PRICES OF METALS . . . MISCELLANEOUS QUOTATIONS

London Market

July	Copper Standard Spot	Copper Standard 3M	Copper Electrolytic Bid	Tin Spot	Tin 3M	Lead Spot	Lead 3M	Zinc Spot	Zinc 3M
1	29.2500	29.6875	32.5000	229.8750	222.3750	13.5625	13.6875	13.8125	14.0625
2	30.1250	30.5000	32.7500	229.7500	225.1250	13.8750	13.9375	13.8750	14.1250
3	30.3750	30.7500	33.7500	230.2500	225.6250	13.8125	13.8750	13.8750	14.1250
4	30.4375	30.8750	33.7500	230.7500	225.0000	13.6875	13.8125	13.7500	13.9375
5	30.1875	30.6250	33.0000	230.2500	224.0000	13.7500	13.8125	13.6250	13.8750
8	29.6875	30.0625	33.0000	230.7500	224.7500	13.6875	13.8125	13.7500	13.8750
9	29.9375	30.3750	33.5000	230.7500	224.5000	13.8125	13.9375	13.8125	13.9375
10	30.3125	30.6875	33.5000	231.0000	224.0000	13.9375	14.0000	13.6875	13.8750
11	31.0625	31.4375	34.0000	231.1250	224.2500	14.0000	14.0625	13.9375	14.0625
12	31.1250	31.5625	34.0000	231.2500	224.5000	14.0625	14.1875	13.8125	13.9375
15	32.0625	32.5000	35.5000	232.0000	224.5000	14.1250	14.1875	13.8750	14.0000
16	32.1250	32.5625	35.5000	232.5000	224.2500	14.1250	14.2500	13.8750	14.0000
17	31.6875	32.1250	35.2500	232.7500	224.5000	14.3750	14.4375	13.8125	14.0000
18	31.3750	31.8125	35.0000	234.7500	224.8750	14.8750	14.9375	14.1250	14.3750
19	31.8125	32.2500	35.0000	236.0000	224.5000	15.0625	15.1875	14.4375	14.6250
22	31.8125	32.2500	35.0000	245.0000	224.7500	15.1875	15.2500	14.5000	14.6250
23	31.8125	32.2500	35.0000	232.5000	223.7500	15.3125	15.3125	14.6875	14.7500
24	31.8125	32.1875	35.0000	233.2500	223.7500	15.3125	15.3125	14.7500	14.7500
25	31.5000	31.8750	34.7500	229.0000	220.0000	15.0000	15.0000	14.4375	14.4375
26	31.0000	31.4375	34.5000	230.5000	220.0000	15.1250	15.1250	14.1875	14.1875
29	31.3125	31.7500	34.5000	233.7500	219.0000	15.1875	15.1875	14.4375	14.4375
30	31.3125	31.6875	34.5000	233.7500	219.0000	15.1250	15.0625	14.2500	14.1875
31	31.4375	31.8750	34.7500	233.6250	218.7500	15.3750	15.3750	14.1875	14.0625
Av. for month	31.024	.....	34.261	232.397	.....	14.451	14.511	14.065	14.185

Current Prices—Miscellaneous Metals, Ores, and Non-Metallic Minerals

Quotations cover wholesale lots, prompt shipment, f.o.b. New York, unless otherwise stated.

(August 1, 1935)

Miscellaneous Metals

Aluminum, ingot, 99 per cent plus, lb.	19@21c.
Antimony, domestic or Chinese (duty paid), lb.	12½c.
Bismuth, ton lots, lb.	90c.
Cadmium, lb.	70c.
Chromium, 97 per cent grade, lb.	88c.
Nickel, electrolytic cathodes, lb.	35c.
Magnesium, 99.8 per cent, carloads, lb.	30c.
Palladium, troy oz.	$24.00
Platinum, (official quotation) troy oz.	$30.00
Quicksilver, flask of 76 lb., 100 flasks or more.	$69.00
Radium, mg. radium content.	$50.00
Selenium, 99.5 per cent, lb.	$2.00
Silicon, minimum 97 per cent. spot, lb.	16.50c.
Tellurium, lb.	$2.00
Thallium, 100 lb. or more, lb.	$6.50
Titanium, 96 to 98 per cent, lb.	$6.00
Zirconium, commercially pure, lb.	$7.00

Metallic Ores

Beryllium Ore, f.o.b. mines, ton.	$30.00@$35.00
Chrome Ore, 45@47 per cent, c.i.f., long ton.	$15.75@$16.50
Iron Ore, Lake Superior, long ton:	
Old Range bessemer	$4.80
Mesabi bessemer	$4.65
Old Range, non-bessemer	$4.65
Mesabi, non-bessemer	$4.50
Lead (Galena) 80 per cent, Joplin, Mo., ton.	$40.00
Manganese Ore, c.i.f. Atlantic ports, long ton unit:	
52@55 per cent.	26c.
49@51 per cent.	25c.
44@47 per cent.	24c.
Molybdenum Ore, per lb. of contained MoS_2.	42c.
Tungsten Ore, per unit of WO_3:	
Chinese, duty paid.	$15.00
Domestic Scheelite.	$14.50
Vanadium Ore, per lb. of contained V_2O_5.	27½c.
Zinc Ore, Prime, 60 per cent concentrate, Joplin, Mo.; per ton.	$29.00

Metallic Compounds

Arsenious Oxide (arsenic) lb.	3½c
Cobalt Oxide, 70@71 per cent, lb.	$1.39@$1.49
Copper Sulphate, 100 lb.	$3.85
Sodium Nitrate, ex vessel, in 200-lb. bags, per 100 lb.	$1.24
Sodium Sulphate, bulk, ton.	$13.00@$15.00

Alloys

Beryllium-Copper, Master alloy, 3.5 per cent Be, per lb. of contained Be.	$25.00
Ferrochrome, 65@70 per cent chromium, 4@6 per cent carbon, lb.	10c.
Ferromanganese, 78@82 per cent, gross ton.	$85.00
Ferromolybdenum, 50@60 per cent Mo, lb. of Mo contained.	95c.
Ferrosilicon, 50 per cent, gross ton.	$77.50
Ferrotungsten, 75@80 per cent, lb. of W contained.	$1.35@$1.45

Non-Metallic Minerals

Asbestos, f.o.b. mines, ton:	
Canadian (Quebec)	
Crude No. 1.	$500@.....
Crude No. 2.	$200@$225
Spinning fibers.	$90@$135
Paper stock.	$32.50@$37.50
Shorts.	$11@$14.50
Vermont	
Shingle stock.	$47@.....
Paper stock.	$35@.....
Cement stock.	$23@.....
Barytes, long ton:	
Georgia, crude.	$7.00
Missouri, 95 per cent $BaSO_4$, less than 1 per cent iron.	$5.50
Bauxite, long ton:	
Domestic, chemical, 55@58 per cent.	$6@ $7.50
Domestic, abrasive, 78@84 per cent.	$12.50@$15.00
Dalmatian, 50@55 per cent.	(a)$4.50@ $6.00
French, 56@59 per cent.	(a)$5.50@ $6.50
China Clay, f.o.b. mines ton:	
South Carolina and Georgia, bulk.	$6.00@ $8.00
Delaware, No. 1.	$14.00@.....
Feldspar, bulk, ton:	
Potash feldspar, 200 mesh.	$17.00
Glass-spar, white, 20 mesh.	$11.75
Fluorspar, f.o.b. mines, bulk, Kentucky and Illinois 85-5 per cent, all rail movement, ton.	$13.00
Fuller's earth, f.o.b. Georgia or Florida, ton.	$7.00@$14.00
Magnesite, per ton:	
Dead-burned, f.o.b. California.	$25.00@.....
Dead-burned, f.o.b. Washington.	$22.00@.....
Mica, per lb., North Carolina, No. 1 and 2 quality:	
1½x2 in.	15@30c.
2x2 in.	30@50c.
2x3 in.	50@65c.
3x4 in.	90@ $1.25
4x6 in.	$1.50@ $2.50
White, ground, 70 mesh, ton.	$60.00@$80.00
Ocher, Georgia, ton.	$19.00@$22.50
Pyrites, Spanish, per long ton unit of S, c.i.f. Atlantic ports.	(a) 12@ 12½c.
Silica, water-floated, in bags, 325 mesh, ton.	$16.00@$40.00
Sulphur, Texas mines, long ton.	$18.00@.....
Talc, f.o.b. works, ton:	
New York, double air-floated, 325 mesh.	$12.00@$15.00
New Jersey, mineral pulp.	$8.00@$10.00
Vermont, extra white, 200 mesh.	$8.50@ $9.00
Tripoli, Missouri, ton:	
40 mesh, cream colored.	$16.00@.....
200 mesh, cream colored.	$26.00@.....

(a) Nominal.

Iron and Steel

Pig Iron, Valley furnaces, gross ton:	
Bessemer.	$19.00
Basic.	$18.00
No. 2 Foundry.	$18.50
Steel, base prices, Pittsburgh:	
Billets gross ton.	$27.00
Structural shapes, 100 lb.	$1.80
Bars, 100 lb.	$1.80

MONTHLY AND YEARLY AVERAGE PRICES

Silver and Sterling Exchange

	Silver New York		Silver London Spot		Sterling Exchange "Checks"	
	1934	1935	1934	1935	1934	1935
January	44.188	54.418	19.382	24.584	504.644	489.207
February	45.233	54.602	20.073	24.818	503.085	487.278
March	45.875	59.048	20.278	27.380	509.259	477.635
April	45.180	67.788	19.740	30.986	515.210	483.596
May	44.226	74.356	19.276	33.865	510.510	488.587
June	45.173	71.940	19.981	32.346	504.721	493.245
July	46.310	68.216	20.512	30.500	503.990	495.558
August	48.986	.....	21.377	.....	506.398	.....
September	49.484	.....	21.888	.....	499.344	.....
October	52.375	.....	23.581	.....	494.019	.....
November	54.255	.....	24.257	.....	498.832	.....
December	54.390	.....	24.404	.....	494.520	.....
Year	47.973	.....	21.229	.....	503.711	.....

New York quotations for silver not eligible for sale to U. S. Government, cents per ounce troy, 999 fine. London, pence per ounce sterling silver 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery Electrolytic Domestic		F.O.B. Refinery Electrolytic Export	London Spot Standard		London Spot (a) Electrolytic	
	1934	1935	1935	1934	1935	1934	1935
January	7.890	8.775	6.583	32.560	28.077	35.614	31.261
February	7.777	8.775	6.341	33.072	27.175	35.969	30.244
March	7.775	8.775	6.526	32.497	28.518	35.512	31.607
April	8.173	8.775	7.328	33.006	31.231	36.038	34.763
May	8.275	8.775	7.794	32.662	33.344	35.756	36.733
June	8.594	8.634	7.307	32.149	30.799	35.339	34.039
July	8.775	7.775	7.350	29.707	31.024	32.778	34.261
August	8.775	.....	.....	28.358	.....	31.483	.....
September	8.775	.....	.....	27.541	.....	30.556	.....
October	8.775	.....	.....	26.753	.....	29.478	.....
November	8.775	.....	.....	27.233	.....	30.222	.....
December	8.775	.....	.....	27.836	.....	31.086	.....
Year	8.428	.....	.....	30.281	.....	33.319	.....

New York quotations, cents per pound. London, pounds sterling per long ton. (a) Bid quotation.

Lead

	New York		St. Louis		London			
	1934	1935	1934	1935	1934 Spot	1934 3 Mos.	1935 Spot	1935 3 Mos.
January	4.000	3.692	3.900	3.542	11.304	11.517	10.321	10.514
February	4.000	3.528	3.900	3.378	11.634	11.913	10.216	10.413
March	4.000	3.579	3.900	3.429	11.545	11.842	11.012	11.188
April	4.179	3.692	4.042	3.542	11.500	11.794	12.231	12.459
May	4.140	3.962	3.990	3.812	11.051	11.341	13.861	13.940
June	3.975	4.020	3.825	3.870	11.054	11.253	13.776	13.806
July	3.772	4.123	3.623	3.973	10.813	11.045	14.451	14.511
August	3.747	.....	3.597	.....	10.821	11.028	.....	.....
September	3.685	.....	3.535	.....	10.388	10.613	.....	.....
October	3.654	.....	3.504	.....	10.359	10.554	.....	.....
November	3.567	.....	3.417	.....	10.432	10.597	.....	.....
December	3.604	.....	3.454	.....	10.316	10.500	.....	.....
Year	3.860	.....	3.724	.....	10.935	11.166	.....	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin

	Straits New York		Standard, Spot London	
	1934	1935	1934	1935
January	51.891	50.916	226.631	231.193
February	51.668	50.063	226.731	227.381
March	53.838	46.962	233.863	215.726
April	55.622	50.154	239.181	223.513
May	53.541	51.138	234.239	227.602
June	51.271	51.108	226.875	227 5*6
July	51.930	52.297	230.381	232.397
August	51.953	.....	228.114	.....
September	51.503	.....	229.888	.....
October	50.951	.....	230.587	.....
November	51.227	.....	228.602	.....
December	50.902	.....	228.178	.....
Year	52.191	.....	230.273	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St. Louis		London			
	1934	1935	1934 Spot	1934 3 Mos.	1935 Spot	1935 3 Mos.
January	4.271	3.730	14.688	14.943	11.994	12.207
February	4.384	3.714	14.844	15.125	11.819	12.000
March	4.368	3.894	14.735	15.033	12.095	12.250
April	4.370	4.030	14.916	15.200	12.891	13.128
May	4.346	4.220	14.722	14.966	14.534	14.685
June	4.240	4.299	14.241	14.467	13.734	13.898
July	4.317	4.325	13.466	13.693	14.065	14.185
August	4.281	.....	13.682	13.756	.....	.....
September	4.049	.....	12.644	12.847	.....	.....
October	3.832	.....	12.217	12.353	.....	.....
November	3.732	.....	12.000	12.281	.....	.....
December	3.711	.....	11.730	12.016	.....	.....
Year	4.158	.....	13.657	13.890	.....	.....

St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Cadmium and Aluminum

	Cadmium		Aluminum	
	1934	1935	(a) 1934	(b) 1935
January	55.000	55.000	23.300	20.000
February	55.000	55.000	23.300	20.000
March	55.000	58.462	23.300	20.000
April	55.000	65.000	23.300	20.000
May	55.000	65.000	23.300	20.000
June	55.000	65.000	23.300	20.000
July	55.000	65.000	23.300	20.000
August	55.000	.....	23.300	.....
September	55.000	.....	23.300	.....
October	55.000	.....	23.300	.....
November	55.000	.....	23.300	.....
December	55.000	.....	23.300	.....
Year	55.000	.....	23.300	.....

Aluminum in cents per pound, 99 per cent grade. (a) Based on Aluminum Company's quotation. (b) Open market price.
Cadmium, cents per pound.

Antimony, Quicksilver, and Platinum

	Antimony (a) New York		Quicksilver (b) New York		Platinum (c) New York	
	1934	1935	1934	1935	1934	1935
January	7.198	14.111	67.538	72.760	38.000	34.000
February	7.172	14.250	72.011	72.500	38.000	34.000
March	7.545	14.250	75.472	72.500	38.000	32.846
April	7.918	14.029	75.930	72.500	38.000	32.000
May	8.465	12.712	75.577	72 135	36.538	32.000
June	7.900	12.500	75.000	71.460	36.000	32.000
July	8.024	12.500	75.000	70.538	36.000	32.000
August	8.514	.....	75.000	.....	36.000	.....
September	8.745	.....	74.563	.....	35.000	.....
October	9.361	.....	74.000	.....	35.038	.....
November	12.239	.....	73.283	.....	35.000	.....
December	13.730	.....	73.000	.....	35.000	.....
Year	8.901	.....	73.865	.....	36.465	.....

(a) Antimony quotations in cents per pound, for ordinary brands. (b) Quicksilver in dollars per flask of 76 lb. (c) Platinum in dollars per ounce troy.

Pig Iron

	Bessemer		Basic		No. 2 Foundry	
	1934	1935	1934	1935	1934	1935
January	18.00	19.00	17.00	18.00	17.50	18.50
February	18.00	19.00	17.00	18.00	17.50	18.50
March	18.00	19.00	17.00	18.00	17.50	18.50
April	18.48	19.00	17.48	18.00	17.98	18.50
May	19.00	19.00	18.00	18.00	18.50	18.50
June	19.00	19.00	18.00	18.00	18.50	18.50
July	19.00	19.00	18.00	18.00	19.50	18.50
August	19.00	.....	18.00	.....	18.50	.....
September	19.00	.....	18.00	.....	18.50	.....
October	19.00	.....	18.00	.....	18.50	.....
November	19.00	.....	18.00	.....	18.50	.....
December	19.00	.....	18.00	.....	18.50	.....
Year	18.707	.....	17.707	.....	18.207	.....

Iron in dollars per long ton. F.o.b. Mahoning and Shenango Valley furnaces.

H. C. PARMELEE
Editorial Director

Engineering and Mining Journal

A. W. FISHER
Manager

Published by McGraw-Hill Publishing Co., Inc.

WILLARD CHEVALIER
Vice-President

Recovery Index. Sales of electric energy are setting an almost unprecedented pace this year. There has been a steady upward trend since May, and the rise was continuing in August. Not only was the output of energy then 8 per cent greater than at the same season last year, but it surpassed that of the highest peak last winter and was 6 per cent greater than at the same time in the record year 1929. Present indications are that all-time records will be matched within a few months and that the demand for electricity next winter will be above the highest previous peak. More than half of the energy is sold for industrial power, which makes the present production figures significant as an indicator of improved industrial activity.

●

Vocational Training in mining has been provided by the Educational Department of Southern Rhodesia, under an apprentice system, for boys of eighteen or over. Two years of specialized work will be required at the Bulawayo Technical School. Boys who have had two years of high school training, or who have completed stated courses of study at elementary schools, are eligible. On completion of the course students will be apprenticed for a period of three years. They will be provided with board and quarters while attending the Technical School for £48 per annum.

●

Automobile Output Up 30 Per Cent—Production of automobiles — passenger cars and trucks — in the United States during the first half of 1935 is estimated at 2,240,000 units. This compares with 1,714,263 units in the same time last year and 990,114 units in the January-June period of 1933.

CONTENTS

FOR SEPTEMBER 1935

Volume 136....Copyright 1935....Number 9

Editorials 433

Producing Lead at Galena Smelter..... 435
R. L. Hallows B. M. O'Harra

Gold Placer Mining at Lincoln..... 440
John B. Huttl

Sampling Yellow Aster Tailings..... 444
Alfred B. Sabin

Examining Gold Quartz Mines..... 445
John Carter Anderson

Advance of Alloy Steels..... 450
B. H. Strom

17 Years of Cooperation..... 455
Selwyn G. Blaylock

Chart for Calculating Slime Densities.. 457
C. E. Heinz

Nickel and the U. S. 459
G. W. Pawel

News of the Industry..... 463

Personal Items, Obituaries, Letters..... 475

Book Reviews 478

Equipment News 479

Summary of the Markets..... 482

"Jack." A well-known mining man, Frank Childress, of Joplin, Mo., has decided to play "angel" to miners on government relief. By furnishing capital to obtain leases on 6,000 acres in the Webb City district of Missouri, and letting out these leases to operators, mostly men on relief, many small mines flooded years ago are being unwatered and small-scale workers are bringing on a rising market the "jack" (lead and zinc ore) that built the town of Picher, Okla. Childress said he got tired of walking down the street and seeing men he formerly worked with idle and on relief, and having them tell him their children were hungry. He tried unsuccessfully to get the PWA folks interested in pumping out the mines, so he decided to do the iob himself.

●

Diamonds—Relatively to the average annual consumption of diamonds, the known reserves are by no means excessive, and are in fact, smaller than in the case of almost all other mining products, according to Sir Ernest Oppenheimer, writing in the Centenary Number of the London *Mining Journal*. The commoner qualities of diamonds which cannot be used for jewelry are used for a multitude of industrial purposes, of which rock drilling, glass cutting, and wire drawing are a few. Half the diamonds produced, in weight, are used for industrial purposes.

●

No Midget Coins. In spite of a demand from some States for 1-mill and 5-mill coins for sales-tax purposes, Congress has turned thumbs down on the proposal to add these pieces to United States coinage. The President had suggested a square coin and a round one with a hole in the center, made of zinc, aluminum, or brass.

ENGINEERING AND MINING JOURNAL is published monthly by the McGraw-Hill Publishing Company, Inc., 330 West 42d St., New York, N. Y., U. S. A. Subscription rates, United States, $3 per annum; Canada and other countries in the Americas outside the United States, $4 per annum; elsewhere $5 or 20 shillings per annum. Price per copy 50c. or 2s. Entered as second-class matter June 20, 1879, at the Post Office, New York, N. Y., under the act of March 3, 1879. Printed in U. S. A.

McGRAW-HILL PUBLISHING COMPANY, INC.
330 West 42d St., New York, N. Y.
Cable Address: McGraw-Hill, N. Y.
San Francisco: 883 Mission Street
Chicago: 520 North Michigan Avenue
Washington, D. C.: National Press Building

McGRAW-HILL PUBLISHING COMPANY, LTD.
Aldwych House, Aldwych,
London, W.C.2, England
Cable Address: Backlash, Estrand, London

JAMES H. McGRAW, Chairman of the Board; MALCOLM MUIR, President; JAMES H. McGRAW, JR., Executive Vice-President; B. R. PUTNAM, Treasurer; D. C. McGRAW, Secretary
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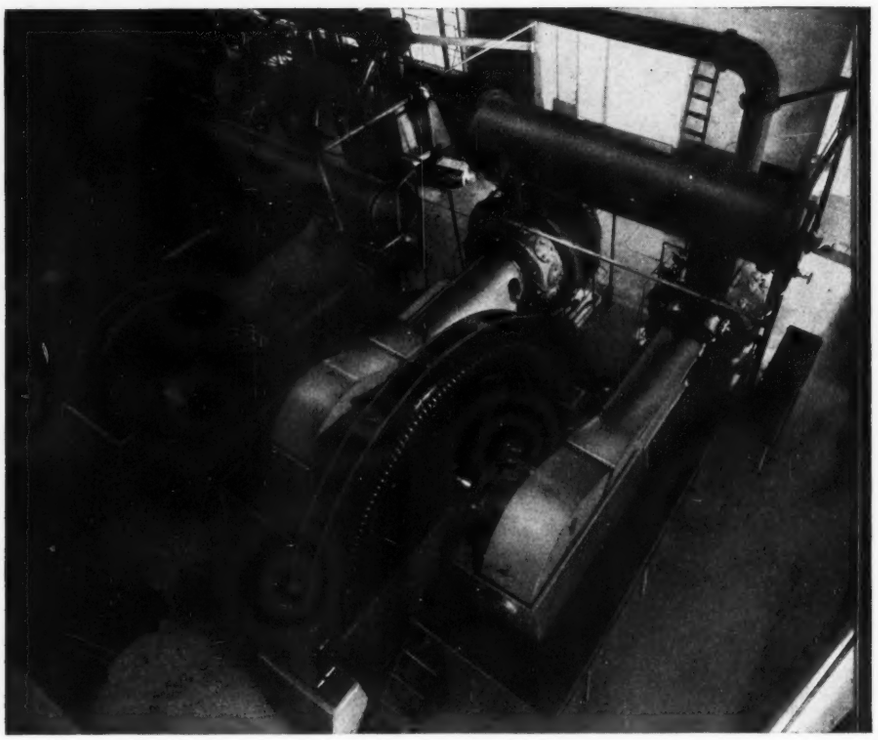

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